

Review of red squirrel conservation activity in northern England

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Foreword

Natural England commissions a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. This report was commissioned jointly by Natural England, Forestry Commission, European Squirrel Initiative and Save our Squirrels, with assistance from Northumberland Wildlife Trust, Red Squirrel Protection Partnership and Northern Red Squirrels. The views in the report are those of the authors and do not necessarily represent those of Natural England or the other commissioning bodies.

Background

The native red squirrel *Sciurus vulgaris*, a UK priority species, has been replaced over most of England by the introduced grey squirrel *Sciurus carolinensis*. The red squirrel is now only found on the Isle of Wight and in parts of Northern England. The reasons for this appear to be that grey squirrels generally out-compete and spread disease to red squirrels.

The aim of this review is to assess the impact on red squirrel populations in the North of England of every organisation involved in developing and delivering red squirrel conservation policies and activities.

The review team looked at all relevant activities undertaken by these organisations since January 2006, critically assessed their approaches, and the impact of these on existing red squirrel populations.

The report confirms that red squirrels are still widely found throughout the North of England, and that the work carried out by the various

organisations has played a significant role in ensuring that people can still see these mammals across a wide area.

The review provides a robust and objective assessment of some aspects of red squirrel conservation work and offers expert and timely advice for future work programmes. Control of grey squirrels is identified as a core part of any future strategy for red squirrel conservation.

The purpose of this report is to help Natural England and the other commissioning bodies:

- Understand what has been achieved over the past 3 years.
- Identify deficiencies in the current strategy and develop ways of being more cooperative and effective.
- Improve the way in which grey squirrel control, central to any red squirrel conservation project, is targeted and delivered.

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Further information

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REVIEW OF RED SQUIRREL CONSERVATION ACTIVITY IN NORTHERN ENGLAND

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1. EXECUTIVE SUMMARY

- The red squirrel *Sciurus vulgaris* has been listed by the Government as a priority species for conservation in the UK biodiversity action plan. Its distribution in Britain has decreased dramatically over the past 70 years, and it is now confined to parts of Scotland, Northern Ireland and northern England, the Isle of Wight and small islands in Poole Harbour, with small remnant populations in Wales.
- The main reason for the decline has been the spread of the non-native grey squirrel *Sciurus carolinensis*, through direct competition for resources, and also by transmitting squirrelpox virus (SQPV) that causes severe clinical disease and mortality in red squirrels.
- Historically, red squirrel conservation efforts have involved grey squirrel control at national or regional level. In recent years, however, the central approach has focussed the limited funding resources on designated reserves (conifer forests) and buffer zones that are managed for red squirrel populations. There are currently 17 designated reserves; the first in 1995, the majority in 2006.
- In the last two or three years the north of England has been the focus of a considerable amount of red squirrel research and conservation work, that has encompassed a number of different approaches. In addition to the reserves, there has been conservation work targeted at the local and regional levels.
- These different approaches were reviewed and evaluated to support the formulation of future cost-effective and sustainable strategies. The review concentrated on the work of four principal organisations: Forestry Commission (FC), Save Our Squirrels (SOS), Red Squirrel Protection Partnership (RSPP) and Local Groups (Northern Red Squirrels).
- Information was collated, from workers within red-squirrel conservation organisations, using a standardised questionnaire and a combination of telephone interview, face-to-face interview and postal survey. Initial 'pilot' interviews were used to assess the effectiveness of the questionnaire, which was modified accordingly prior to circulation to the full list of individuals and organisations.
- Information on conservation activity was requested in the following principal areas: grey squirrel control operations, habitat management, the infrastructure for recording data, access and education provision and raising public awareness.
- In total, responses were obtained from 57 individuals representing 17 organisations and two estates.
- Overall, there are three main problems that are currently impacting on red squirrel conservation work in northern England: lack of funding to support the reserve strategy especially with regard to systematic grey squirrel control, a fragmentation of effort with a lack of a joined up, coordinated strategic direction and public dissonance between 'official' organisations.
- The different approaches by the organisations have led to a divergence in the philosophy and focus of the overall conservation strategy. This has been

exacerbated by a number of factors and perceptions, such as the organisations' differing ethos, personality clashes, and feelings of disenfranchisement from the planning and delivery.

- The current reserve-based strategy was based on squirrel ecology and cost-effective targeting of limited available funding. The nature of some of the designated reserves, however, indicates that their selection was not principally based on science. There is a need to examine the status of some reserves and to look at the potential of other, possibly more suitable sites.
- Overall, efforts to control grey squirrels were uncoordinated and fragmentary. In essence, grey control was reactive in that removal was carried out in response to sightings, rather than being a proactive systematic removal.
- Despite some local successes (e.g. Whinfell reserve), there is no evidence that the grey squirrel control operations carried out for red squirrel conservation in the North of England have had any effect on the regional distribution of grey squirrels and, by implication, population numbers.
- Control was most commonly undertaken using live-trapping supplemented by shooting free-ranging individuals. It was heavily dependent on the efforts of volunteers, either to carry out the trapping (trap loan schemes) and despatching of squirrels, or to allow trapping to be carried out on their land; there was a lack of consensus on best practice. To maintain high standards of animal welfare during control operations, it would be preferable if full-time, professional operatives carried out control, although additional assistance from volunteers, appropriately trained and supervised, should not be excluded.
- No systematic survey work on squirrel abundance or recording of control effort (e.g. trap nights per capture) was carried out against which to measure the effectiveness of control operations. Consequently, it was impossible to assess the temporal and spatial effects of control in terms of changes in the local abundance and distribution of either grey or red squirrels.
- Recommendations for future grey squirrel control include the formulation of Standard Operating Procedures, an independent field audit of trapping and despatch methods, proactive systematic control, recording of trapping effort and systematic monitoring of squirrel populations.
- Habitat management is carried out only by the Forestry Commission, whilst SOS provide management advice to landowners. As habitat management is a long-term option, the three-year focus of the review was, therefore, too short a time frame to draw any conclusions with regard to effectiveness and success; although activities do appear to follow best practice.
- Data recording is largely fragmentary, unsystematic and non-standardised between different organisations and groups. In general, insufficient data are recorded to allow anything other than a rudimentary evaluation of conservation efforts.

- A series of data collection measures and protocols need to be introduced and standardised across northern England. Standardised surveys are required, at different spatial and temporal scales, to record the abundance and distribution of red and grey squirrels, and to evaluate control effort.
- Detailed GIS maps need to be produced and maintained that record a variety of parameters, including squirrel abundance and distribution, sightings, landownership, control operations and habitat management.
- With respect to access and engagement activities, SOS performance target outputs and increases in the number of regional newspaper articles related to the issue of red squirrel conservation indicate that the campaign has successfully delivered the red squirrel conservation message; and presumably awareness levels in the general public have been increased. However, it is unclear how an increased level of awareness is translated into practical conservation success on the ground.
- Overemphasis on, and the delivery of awareness-raising performance targets has been accompanied by under-delivery of practical conservation activities. Although awareness raising is an essential component in any future strategy, it needs to be proportionately resourced and targeted more strategically.
- Looking towards a future strategy, the priority and first fundamental step, with leadership by the statutory agencies, should be a renewed effort to agree a coordinated approach with all willing organisations and voluntary squirrel groups for the North of England and to include a strong link to efforts in Scotland.
- A future strategy has to be much more inclusive, with wider engagement and strategic coordination between the different organisations, including local groups and landowners.
- The three key components of any future red squirrel conservation strategy are grey squirrel control, conservation, and community engagement; each must involve annual targets and reviews.
- Four potential options for a future red squirrel conservation strategy are presented: (i) do nothing, (ii) have a reserve-based strategy, (iii) have a landscape-based strategy, and (iv) eradicate and maintain absence of grey squirrels from northern England.
- The estimated indicative costs for these strategies are: (i) do nothing – costs for the outstanding years of the SOS campaign covered by existing funds; (ii) a reserve-based strategy - year 1 £495k, year 2+ (annually) £320k; (iii) a landscape-based strategy - year 1 £660k, year 2+ (annually) £410k; (iv) regional eradication - year 1 £1.5m, year 2+ £1.0m (annually).

2. INTRODUCTION

The red squirrel *Sciurus vulgaris* has been listed by the Government as a priority species for conservation in the UK biodiversity action plan. Its distribution in Britain has decreased dramatically over the past 70 years, and it is now confined to parts of Scotland, Northern Ireland and northern England, the Isle of Wight and small islands in Poole Harbour, with small remnant populations in Wales. The main reason for the decline has been the spread of the alien grey squirrel *Sciurus carolinensis*. Grey squirrels cause red squirrel decline by directly competing with red squirrels for resources, and also by transmitting squirrelpox virus (SQPV) infection which causes severe clinical disease and mortality in red squirrels but has no apparent effect on greys.

In northern England, the decline of the native red squirrel is a relatively recent event compared to the introduction of the North American grey squirrel over 130 years ago (Middleton 1930). Until the late 1990s and early into this century the species was widespread in Cumbria, County Durham and Northumberland. Even now the species is commonly found in the northern parts of Cumbria and Northumberland and still present in County Durham, the North Yorkshire Dales and Sefton in Merseyside.

In the last two or three years the north of England has been the focus of a considerable amount of red squirrel research, and conservation work on, for example, minimising grey squirrel spread and reducing the risk of disease transmission between species. The latter is particularly crucial with respect to the 16 designated red squirrel refuge areas in Northumberland, Cumbria and Lancashire. Red squirrels in northern England represent the last remaining viable population of reds in England (other than the island populations), but are vulnerable to invasion by grey squirrels and to disease outbreaks caused by SQPV and the recently discovered adenovirus (Sainsbury *et al.* 2001, Duff *et al.* 2007, Everest *et al.* 2008).

Regionally and nationally in England, the formation of a large number of organisations such as Red Alert, European Squirrel Initiative, Northern Red Squirrels, Red Squirrel Protection Partnership and the Red Squirrel Survival Trust reflects an intense interest in red squirrels and a locally widespread support for conservation action and management. Northern Red Squirrels alone, an umbrella organisation, encompasses 45 regional groups across Cumbria and Northumberland (<http://www.northernredsquirrels.co.uk/main.html>). Similarly, the extensive media coverage of red squirrel decline caused by the range expansion of grey squirrels illustrates the widespread public engagement and the sometimes complex and emotional nature of the issue (Fig. 2.1). This is particularly true with regard to red squirrels dying from squirrelpox virus (SQPV), the designation of reserves, and attempts to control grey squirrels for red squirrel conservation.

The activities of the various red squirrel conservation organisations have encompassed a number of different approaches, focusing on habitat management, raising public awareness, grey squirrel control and fund raising for both conservation and research activities (Fig. 2.2).



Figure 2.1. Example of newspaper clippings to illustrate the interest in red squirrel conservation.

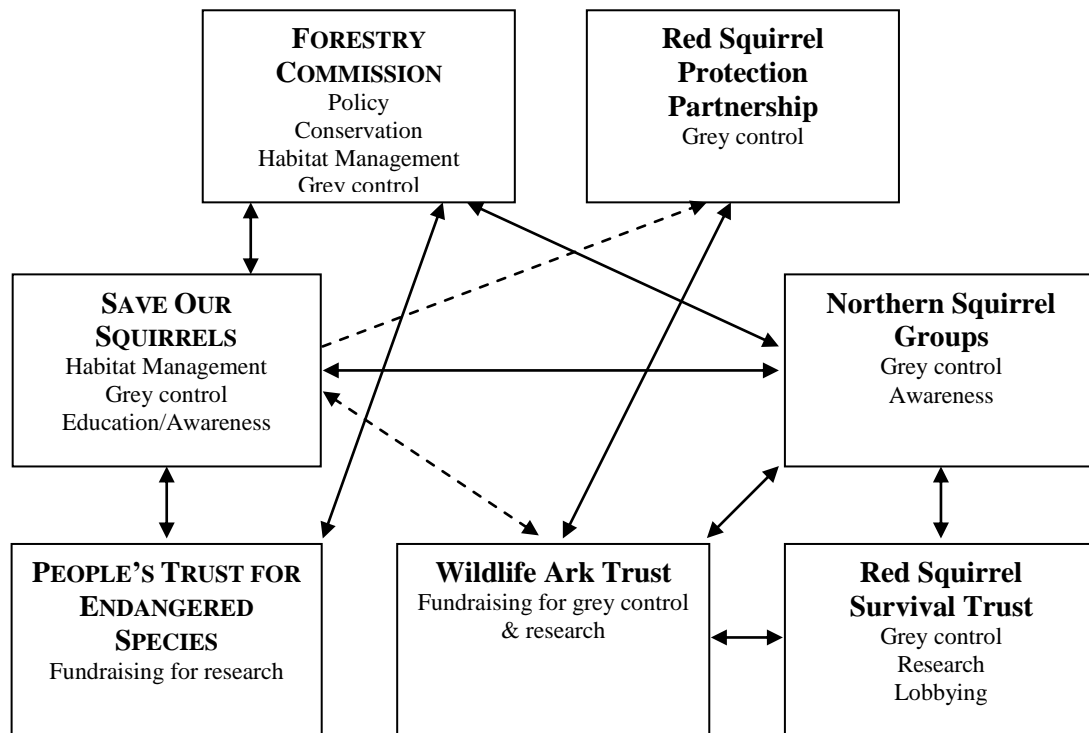


Figure 2.2 Simplified diagram indicating the relationships between key squirrel organisations active in the north of England and the aspects their main conservation efforts are focused on. Arrows are based on information given by both organisations where possible; not all organisations provided feedback.

3. AIMS AND OBJECTIVES

The report reviews and evaluates the red squirrel conservation work that has been undertaken in northern England over the last three years (2006-2008). The review principally focuses on the activities of the Forestry Commission (FC), Save Our Squirrels (SOS), Red Squirrel Protection Partnership (RSPP) and Local Groups (Northern Red Squirrels), including the activities:

- Grey squirrel control operations.
- Habitat management.
- Recording sightings, data collection and analysis.
- Awareness raising - providing access and education.

The overarching aim of the review and evaluation is to support the formulation of future cost-effective and sustainable strategies.

In addition to the four principal conservation organisations, the review also includes input from a number of other organisations, including those in southern Scotland and Anglesey, North Wales, whose work is considered of relevance to informing the development of future conservation strategies for northern England.

The report comprises a number of main sections:

- Section 4: a brief review of the background to the decline of red squirrels and associated conservation efforts;
- Section 5: the collation of information on the conservation strategies carried out by the different organisations;
- Section 6: maps illustrating red and grey squirrel distribution in northern England, during six-monthly periods between July 2005 and June 2008;
- Section 7: a review and evaluation of the current overall strategy;
- Section 8: a review and evaluation of grey squirrel control;
- Section 9: a review and evaluation of habitat management;
- Section 10: a review and evaluation of data collation;
- Section 11: a review and evaluation of awareness raising activities; and
- Section 12: presentation of four costed options for a future strategy.

4. BACKGROUND

4.1 CONTEXT

Red squirrel distribution in England has suffered a catastrophic decline over the course of the last century and significant populations now only remain on some offshore islands and in northern England. Whilst changes in land use, forest fragmentation and human impact may have locally played a part, there is no doubt that the main cause for the widespread disappearance has been competition by the introduced North American grey squirrel. In the absence of the grey squirrel, red squirrels would still be present throughout England in all woodlands of suitable composition and age structure as well as suburban areas, gardens and parks.

4.2 POLICY

Red squirrels are protected under the Wildlife and Countryside Act and listed on Appendix III of the Bern Convention. A species action plan has been prepared – action plan objectives and targets for the species (www.ukbap.org.uk) were:

- where appropriate, maintain current populations of red squirrels;
- where appropriate, enhance current populations of red squirrels; and
- where appropriate, re-establish red squirrel populations.

The original action plan was amended in 2006, however, to the single objective:

- maintain populations of red squirrels across their current range in the UK.

4.3 HISTORY (PRE NOVEMBER 2005)

In order to understand national efforts to ensure red squirrel persistence and to set them into context, it is important to understand the nature of the competitive interactions between red and grey squirrels and the relative importance squirrelpox virus (formerly parapox virus, Thomas *et al.* 2003) is considered to have in this process. This introductory section is therefore split into three sub-sections that briefly summarise red-grey squirrel competition, the history of the squirrelpox virus (SQPV) and the history of conservation efforts prior to the focus of the current review (2005-2008).

Interactions between red and grey squirrels are thought to be two-fold in that they compete for resources and in some regions of the UK, grey squirrels may be acting as a vector for a virus (SQPV) linked to high mortality in red squirrels. Initial efforts to elucidate the mechanisms of red-grey squirrel interactions were mainly focused on competition. The synergistic role of SQPV in red squirrel decline in England was not fully recognised until sufficient data were available to demonstrate its impact.

It is important to note, however, that data from Italy and Scotland (prior to SQPV spreading there) clearly show that grey squirrels have the capacity to replace red squirrels through competition alone (Bryce 1997, Usher *et al.* 1992, Wauters *et al.* 1997). Observed decline then tends to be slower and the extent will be influenced by habitat type, landscape structure and factors that affect dispersal behaviour (Gurnell *et al.* 2004).

4.3.1 Red-grey squirrel competition

There has been an understandable tendency to simplify red-grey squirrel interactions and the causes of red squirrel decline. However, there is no evidence that grey squirrels aggressively chase out red squirrels or interfere with their mating behaviour. Nor do greys eat hazel nuts before the reds – both species will feed on them while green in north of England.

Furthermore, both species have the same breeding potential (Koprowski 1994, Lurz *et al.* 2001) and red squirrels are for example, equally capable of producing record litters of seven young as recently reported from Italy (Mari *et al.* 2008). However, reproductive success is closely linked to body condition. Research in Italy and the UK has shown that grey squirrels do occur at significantly higher densities in deciduous and some mixed woodlands (Gurnell *et al.* 2008). Competition for resources in these habitats, including the reported pilfering of red squirrel caches by grey squirrels (Wauters *et al.* 2002) as well as differences in their respective abilities to exploit food resources such as acorns (Kenward & Holm 1993) will impact on local red squirrel populations.

Measurable effects in studies on red squirrels have been reduced growth in young squirrels, fewer females producing a second litter in the summer and significantly reduced juvenile recruitment in red squirrel populations where grey squirrels were present (Wauters *et al.* 2000, 2002, Gurnell *et al.* 2004).

It is easy to understand that the combined impacts of these observed competitive effects could lead to a decline in the size of the local red squirrel population and over time, its extinction. It is, however, important to note, that landscape structure, habitat composition and the availability of food resources in time and space will influence this process (Gurnell *et al.* 2004). Historical evidence and data on squirrel distributions has shown that the decline is widespread and that it can be very rapid in deciduous habitats (e.g. Middleton 1932, Shorten 1954, Lloyd 1962, 1983, Skelcher 1997). In contrast, in some large conifer forests red squirrels have persisted for decades in the presence of grey squirrels (e.g. Bryce 2000, Teangana *et al.* 2000).

This led to the suggestion of the concept of designated conservation areas for red squirrels in the late 1980s (Gurnell & Pepper 1988) and for both conservation and research efforts to be targeted at large conifer forests (Gurnell & Pepper 1993, Lurz *et al.* 1995, 1998, Pepper & Patterson 1998). Ironically, this meant that the future of a native species was linked to a habitat type that in practice is dominated by non-native North American (e.g. Sitka spruce *Picea sitchensis* or lodgepole pine *Pinus contorta*) and European conifer species (e.g. Norway spruce *Picea abies*, larch *Larix decidua*).

4.3.2 Squirrelepox virus

Reports of disease in red squirrels have not been a recent phenomenon. Like all wild animals, red squirrels are affected by both disease and internal and external parasites (Gurnell *et al.* 2008, Lurz *et al.* 1995). There is, however, no systematic, comprehensive monitoring or screening of squirrel populations. Knowledge about different pathogens and parasites has therefore relied on dedicated individuals, specific projects or chance discoveries.

Population crashes in red squirrels were reported from different parts of the British Isles between 1900-1924 (Middleton 1930, Shorten 1954). Disease was the main reason given for the declines. Initially, the possibility of the grey squirrel as a carrier

of disease affecting red squirrels was discounted. However, in 1971 a disease resembling myxomatosis in red squirrels was described in Norfolk (Keymer 1974) and attributed to a parapoxvirus in 1981 (Scott *et al.* 1981). Clinical examinations of red squirrels in Thetford Forest, Norfolk suggested that the same virus caused the death of two red squirrels in the early 1990s (Sainsbury & Gurnell 1995) and could be a significant threat to remnant populations in England.

Progressive outbreaks of the disease in red squirrels in Lancashire, Cumbria and Northumberland (e.g. Sainsbury & Ward 1996, Sainsbury & Gurnell 1997, Rushton *et al.* 2006), made clear that there was an apparent link between the observed arrival and subsequent spread of grey squirrels into the area and the incidence of the disease in red squirrels. Furthermore, work in 2000 demonstrated that the observed patterns of red squirrel decline were consistent with replacement through an interaction of competition and disease (Rushton *et al.* 2000). Testing of grey squirrels for antibodies to the virus in the late 1990s revealed that on average 61% of apparently healthy grey squirrels in populations in England had been exposed to the virus (Sainsbury *et al.* 2000). However it was unclear how the virus was transmitted between individuals of either species.

Research in 2002 confirmed that the virus was highly pathogenic in red squirrels with no detectable effects in greys (Thompkins *et al.* 2002). DNA sequence data and microscopic examination of the parapoxvirus revealed that the virus represented a previously unrecognised genus of the *Chordopoxviridae* and should be described as a squirrelpox virus (SQPV) instead (Thomas *et al.* 2003). An examination of forest cover in the north of England highlighted the risk of SQPV spread from the Solway area in Cumbria into southern Scotland (Lurz *et al.* 2003) and a paper by McInnes & Nettleton calling for research funding on SQPV transmission and vaccine development (see also Sainsbury *et al.* 2000) was presented by John Gurnell to the UKRSG (see UKRSG minutes May 19th 2004).

Analysis of blood samples from grey squirrels in the USA showed antibodies to the virus, supporting the suggestion that some squirrels may have brought the virus with them on introduction to the UK (McInnes *et al.* 2006). There were originally 33 separate, recorded introductions and translocations of North American grey squirrels within the UK. Numbers released ranged from 2 to 100 individuals from different source populations in North America and later from within the UK (Middleton 1930).

An attempt to quantify the impact of the virus on red squirrel populations was published in 2006. An analysis of public squirrel sightings of both species from areas with and without SQPV showed that decline (measuring area over which reds had been lost) was 17-25 times higher in areas where the virus had been reported (Rushton *et al.* 2006). The research also demonstrated that an effective grey squirrel control strategy would have to operate on a landscape level and that, for an established population, a >60% effective kill rate would be needed to halt the decline of red squirrels in Cumbria.

This led to the preparation of a disease contingency plan for Kielder Forest with a call for a precautionary approach that included monitoring and targeted control of grey squirrels in potential dispersal corridors leading into the forest (Lurz *et al.* 2005).

The principle of a precautionary approach advocating the targeted control of grey squirrels in order to prevent disease transmission was supported further by evidence that suggested grey squirrels were the reservoir host for SQPV (Sainsbury 2008). Sainsbury (2008) highlighted again the need for a better understanding of SQPV epidemiology and transmission.

4.3.3 Conservation efforts

There have been widespread and dedicated efforts to conserve red squirrels all across the UK, but a detailed description and chronology would go beyond the scope of this review. This section, therefore, attempts to give a brief overview of red squirrel conservation efforts in the North of England from the late 1980s to the present.

Nineteen eighty-seven saw the start of Graeme Skelcher's project in Lancashire and Cumbria which was supported by Arnsdale Silverdale AONB Countryside Management Service, Cumbria Wildlife Trust and People's Trust for Endangered Species (PTES) (Skelcher 1994). An interest and growing awareness of red squirrel decline by landowners at the time is illustrated by the 1989 Royal Forestry Society and Timber Growers Association's red squirrel survey of their members. In 1990, The Red Alert project with its distinctive logo was set up in the north-east of England and launched by the Northern Rock Building Society in Newcastle in 1991. Its aims were to raise public awareness of the threat to the red squirrel (Fig. 4.1) and to support research efforts into red squirrel ecology in Sitka spruce dominated forests (Stewart 1997). The project was supported by Viscount Ridley, Forestry Commission, conservation agencies and the Wildlife Trusts of Durham and Northumberland.



Figure 4.1. Information pack of Red Alert project 1991.

In 1993, NPI Red Alert North West was established in the north-west of England. Conservation organisations, landowners and business as well as local groups came together for a widely supported project. Three conferences on red squirrel conservation including a Squirrel Forum were held in 1994, 1995 and 1998 (see SOS Project Business plan and Stewart 1997). These Wildlife Trust led initiatives were very effective in raising public awareness and provided a focus for the collection of squirrel records and data on red and grey squirrel distributions.

In 1995, Forestry Commission, Kielder Forest District (McIntosh, 1995, Lurz 1995) took a lead in designating Spadeadam Forest as the first red squirrel conservation

area. Nineteen ninety-five also saw the publication of the Biodiversity Challenge document with a Biodiversity Action Plan followed by a UK strategy for red squirrel conservation in 1995 (Anon. 1995).

The PTES held a symposium in 1997 (Gurnell & Lurz 1997) to provide an overview and a basis for future directions in red squirrel conservation and research. The meeting gave an account of the efforts of conservation groups (Stewart 1997) and the knowledge on competition between the two squirrel species. It highlighted the emergent threat of SQPV and the need for more information on the epidemiology and transmission of the virus and the feasibility of a vaccine for the disease (Sainsbury *et al.* 1997). It also led to efforts supported by Forestry Commission, PTES and JNCC to investigate habitat suitability for a network of red squirrel conservation areas in mainland Britain (Rushton *et al.* 1999) with a presentation of the results to UKRSG in 2000.

In parallel to the development of a reserve-based approach to red squirrel conservation (Gurnell & Pepper 1988), Forestry Commission and PTES supported projects to develop and implement management guidelines for red squirrels in large Sitka spruce dominated plantations (1998-2001). The joint PTES and Forestry Commission Kielder Red Squirrel Project (2001-2003) was completed in the summer of 2003 and the main block of Kielder Forest, Kidland and Usway Forest were designated and launched as squirrel reserves (Lurz *et al.* 2003).

Wildlife Trusts put together an outline bid to the Heritage Lottery Fund (UKRSG minutes 17th Dec. 2002) for a network of squirrel reserves with agreed management plans. The process of developing management plans for squirrel reserves was extended to other sites in 2002 (e.g. Sefton, SOS Project Business plan).

A standard national monitoring scheme was proposed by PTES and JNCC in 2004. Richard Pow (FC) prepared the full bid to Heritage Lottery Fund in collaboration with Wildlife Trusts (UKRSG minutes 19th May 2004).

Heritage Lottery Fund grants funding and Save our Squirrels Project covering 16 squirrel reserves in the north of England launched in July 2006 (<http://www.saveoursquirrels.org>). Wildlife Trust and Forestry Commission bring together primary stakeholders in the Red Alert North England (RANEng) steering group, comprising statutory agencies, National Parks, Forestry Commission, voluntary sector conservation organisations and private organisations (see RANEng Terms of Reference, R. Pow pers. Comm.).

Red Squirrel Protection Partnership was formed in 2006 with the stated aim to help save red squirrels through grey squirrel control via a network of monitors to detect grey squirrel incursions in designated areas of land in red squirrel zones.

Wildlife Ark Trust and PTES funded a project at Liverpool University to investigate the genome of SQPV, in early 2008. Northern Red Squirrels, an umbrella organisation for 45 local squirrel groups in Cumbria and Northumberland, was set up in November 2007 and launched in March 2008. Wildlife Ark Trust commissioned the first phase of research into the feasibility of a vaccine at the Moredun Institute in Scotland in autumn 2008.

4.4 OVERVIEW OF CURRENT RESERVE STRATEGY: LOCAL RESERVE-BASED VERSUS REGIONAL

“The red squirrel will survive if programmes are properly resourced and conservation actions are targeted and effective...” (Stewart 1997).

Conservation strategies linked to short or medium term grey squirrel control can broadly be divided into regional, large-scale or local, reserve-based approaches. Historically, efforts have generally been applied on a large-scale and awareness campaigns and attempts to control the introduced grey squirrel are nothing new. During the 2nd World War, a conference of county pest officers was organised in 1944 by the Ministry of Agriculture to raise awareness on the 'squirrel menace'. Free cartridges were made available to registered clubs and by 1947 some 450 Grey Squirrel Shooting Clubs had been accredited with 100,000 killed grey squirrels. By March 1952 this scheme included 7,000 clubs. Yet neither this scheme nor the later bounty scheme introduced in 1953 with 361,636 grey squirrels killed by March 1954 and 391,891, 156,276, 235,586 and 374,915 in subsequent years, failed to either reduce the overall population of grey squirrels (Rowe 1983, Sheail 1999) or to halt their continued range expansion (Lloyd 1983). Later analysis concluded that the only impact on overall population size was not due to culling but a year with a poor seed mast (Sheail 1999).

A detailed examination of all past records goes beyond the scope of the current review. However, we suggest that the following factors may have contributed to the failures of the grey squirrel control cartridge and bounty schemes: there was a national aim but no systematic national or regional strategy; there was no initial estimate of the total cost of control; it may not have provided the right incentives; in some areas it started too late, regional control infrastructure lagged behind colonisation; it stopped too soon due to escalating costs; there was no measure of the impact of culling on Grey squirrel population dynamics, bag size *per se* is not the right measure, what is important is remaining population density following control.

Similarly, efforts by Wildlife Trusts (Red Alert project) from 1991 onwards in the north of England were initially based on a regional approach for Cumbria, Northumberland and parts of County Durham. The project included the setting up of local groups, trap loan schemes and an awareness campaign. However, given the limited resources available for Red Alert in North of England, efforts did not succeed in halting grey squirrel spread either in Cumbria or Northumberland. Furthermore, disease outbreaks of SQPV led to a catastrophic decline in red squirrel populations in the south of Cumbria by 2003 (Rushton *et al.* 2006).

The reality of limited available resources is also reflected in decisions taken by the UKRSG which noted in July 2005 (UKRSG minutes 5th July 2005): "It has been deemed that the risk to peripheral RS populations in some areas is too great for our limited ability to control GS populations, it is not realistic to set targets that state we will maintain the current range."

The concept of conservation areas had originally been suggested by Gurnell and Pepper (1988) (see also section 4.3) and advice given to Forestry Commission by scientists was to focus limited resources into conifer dominated areas (reserves or refuges) where they had the best chance of success in retaining viable red squirrel

populations. In these conifer forests, grey squirrels would not have the competitive advantage they enjoyed in deciduous woodlands. In addition, their densities would be low and thus encounter and transmission rates for SQPV would also be low. This approach led to the designation of conservation areas at Spadeadam forest in 1995, Kielder, Kidland Forests and Usway Ford in 2003 and the SOS project in 2006.

5. WORK OF CONSERVATION ORGANISATIONS

Information on red squirrel conservation activity was collated using a standardised questionnaire (Appendix 1) and a combination of telephone interview, face-to-face interview and postal survey. Initial ‘pilot’ interviews were used to assess the effectiveness of the questionnaire, which was modified accordingly prior to circulation to the full list of individuals and organisations. The Project Steering Group provided an initial list of prospective interviewees. This list was supplemented by the inclusion of further individuals identified by interviewees during the interview programme. The organisations and their respective number of interviewees are presented in Appendix 2.

Questionnaire returns were examined and information extracted and presented in four categories: (i) grey squirrel control, (ii) habitat management, (iii) data (i.e. the infrastructure for recording sightings, control effort, surveys, etc.), and (iv) awareness raising (i.e. the provision of information and education). This section summarises that information for each organisation. Returns from different individuals within an organisation were condensed to give a single overview. A critical evaluation of activities in each of the four categories is presented in later sections.

5.1 SAVE OUR SQUIRRELS (SOS)

Save our Squirrels was created by Red Alert North England (RANEng) (see below) to deliver the North of England Red Squirrel Conservation and Access Strategy. It was launched in 2006 and is managed and directed by the Northumberland Wildlife Trust. The project's headquarters are in Newcastle with regional offices hosted by the wildlife trusts in Cumbria and Lancashire (<http://www.saveoursquirrels.org>).

The stated aims of SOS are:

- i. To raise the profile and plight of the red squirrel through working with schools and other educational institutions; involving local communities and the general public in red squirrel conservation; and providing places where people can see and engage with red squirrels in the wild.
- ii. To work with landowners and managers in the 17¹ designated Red Squirrel Reserves, and their surrounding Buffer Zones, to develop and maintain good quality habitat for red squirrels and eliminate any grey squirrels that enter the area.
- iii. To secure the long-term future and sustainability of red squirrel conservation, access and public engagement activities until a deliverable vaccine against the squirrelpox virus is developed.

The project has a budget of £1.15m for the period July 2006 to July 2010 to undertake the programme of work. Over 50% of this budget has come from the Heritage Lottery Fund (HLF), with the balance being funded by the public and private sector businesses that make up Red Alert North England, corporate sponsorship, and donations from the general public.

Red Alert North England is described as “a grouping of organisations that provided the impetus, expertise and authority to drive the red squirrel conservation strategy

¹ note that this extract from the SOS website includes the new reserve at Greenfield in North Yorkshire Dales, originally 16 reserves were designated.

forward'. The RANEng Steering Group comprises: statutory agencies, private organisations and voluntary conservation bodies and partnerships (Fig. 5.1).

RED ALERT NORTH ENGLAND COMMITTEE
Private Individuals & Landowners
National Parks
Northern Red Squirrels
Forestry Commission
United Utilities plc
SoS Project
Red Squirrels in South Scotland (RSSS)
Wildlife Trusts (Cumb., Lancs., Northumb.)
Centre Parcs
Natural England
Northumbrian Water plc
National Trust
European Squirrel Initiative
Confederation of Forest Industries

Figure 5.1. Composition of Red Alert North England Steering Committee (RANEng).

5.1.1 Control of grey squirrels

There has been an inherent difficulty in delivering the SOS project aim of eliminating grey squirrels that enter reserves and buffer zones (see above) as the agreement with HLF for the lottery and matched funding stipulated that they were not allowed to carry out grey squirrel control (see also UKRSG minutes 7th Nov. 2007). This meant that in terms of grey squirrel control the project could only advise on best practice, assist with grant applications for landowners in and around reserves and run a trap loan scheme. These problems were overcome with additional funding and SOS now employ two control operatives, one in the north of Cumbria and one at Sefton who have been in post since March 2008 and June 2008 respectively. SoS reports possession of in excess of 1300 traps, 1000 of which are on permanent loan from Red Squirrels in South Scotland.

Methods of grey control involve shooting and trapping of grey squirrels with subsequent despatch of individuals using the 'Sack' method or shooting in the trap. Interviews indicated that shooting in the trap was preferred to the 'Sack' method. The aims of the control are to remove grey squirrels from reserves and buffer zones, prevent the risk of SQPV transmission and to reduce grey squirrel numbers outside the buffer zone to reduce immigration. To that extent, the control operatives work with volunteers, landowners and local squirrel groups and in the case of Cumbria, run a trap loan scheme. At Sefton, control (carried out by volunteers before June 2008) has not prevented SQPV from penetrating (present since October 2007) into the reserve. Currently, trapping is carried out during late winter, spring and early summer and shooting at other times (see also section 8). Data provided for northern Cumbria list 77 grey squirrels despatched and for Sefton 206 grey squirrels between 2005 and 2008(part), although the latter figure is considered an underestimate, as it takes no account of squirrels killed by volunteers and gamekeepers.

5.1.2 Habitat management

SOS do not manage habitat within the reserves or buffer zones but provide advice both on their website and through the dedicated conservation officers.

5.1.3 Data

Data on grey squirrels are stored digitally (Excel spreadsheet) and contain information on the contact details of the recorder, date, grid reference, whether the record was verified, location and habitat details, age, sex and cause of death details for the squirrel as well as if the body has been sent for postmortem and if a blood sample has been taken and its results. Data provided for the current review contained 2,802 grey squirrel records (Aug 2006-Nov. 2008) and 4,075 red squirrel records (March 2006-Nov. 2006). Data are reported to be shared with stakeholders, local groups, UKRSG and other interested parties.

5.1.4 Awareness raising

SOS has a team tasked to deliver an ‘access and engagement strategy’ (SOS business plan). There are quarterly project performance targets which include for example press, media, TV and radio targets, and very detailed targets for e.g. disabled, elderly and youth visits to reserves, classroom sessions with primary schools, activities with secondary schools or the distribution of red squirrel literature to tourism businesses.

The SOS website provides information on conservation, learning links, news and events as well as the squirrelpox virus, red squirrel reserves, management advice, squirrels and the law, grey control, monitoring and research. SOS also provides a wide range of leaflets and information materials.

5.2 FORESTRY COMMISSION (FC)

Forestry Commission own and manage some of the larger designated red squirrel reserves (e.g. Kielder Forest, Whinlatter). They have been a key partner in the efforts to conserve the red squirrel across Britain and have been supportive of red squirrel research for conservation in England, Wales and Scotland. Forestry Commission staff have been instrumental in making the bid to HLF possible and in overcoming differences between organisations at the time. Forestry Commission currently hold the chair of the RANEng Steering Committee, that aims to encourage and co-ordinate red squirrel conservation in northern England (see RANEng Terms of Reference in Appendix 3).

5.2.1 Control of grey squirrels

The main method of control is trapping (single-capture traps) with grey squirrels being despatched using the ‘Sack’ method. Some free-ranging grey squirrels are also shot. FC controls grey squirrels for red squirrel conservation and state that it is part of an ongoing programme of control as well as in response to systematic monitoring and public sightings. The aim is to remove grey squirrels from designated red squirrel reserves and to prevent SQPV transmission. Target areas for the control are, therefore, the red squirrel reserves and buffer zones. Monitoring is carried out before, during and after control.

In addition, monitoring is also carried out within red squirrel reserves. The cost of an independent systematic annual squirrel survey at the Kidland Forest reserve (2001-2008) has been £1,000 a year until 2007 and £1,200 in 2008.

FC is also supporting grey squirrel control with grants (English Woodland Grant Scheme EWGS) and records indicate that 22 grants for £50,132 were awarded for woodlands in reserves and buffer zones in Cumbria with a total of 1,042 grey squirrels controlled to date. Records for Northumberland indicate a total of 17 grants for £35,673 with 515 grey squirrels controlled to date. Note that grey squirrel control is ongoing and cost estimates for both regions include active grants with money not yet claimed. FC also funds grey squirrel control on FC land and annual costs for Kielder are estimated at £17k with a total of 177 grey squirrels killed last year.

5.2.2 Habitat management

FC carries out habitat management for red squirrels on FC woodlands within reserves and buffer zones. Work, for example, includes the planting of conifers to diversify the seed food supply, the planting of small-seeded broadleaves, and the provision of dispersal corridors for squirrels within reserves. Costs for this work are difficult to calculate but it has been estimated that restructuring work at Kielder Forest that includes habitat management for red squirrels is likely to be £18m over the next 20 years.

FC also provides grants for habitat management for red squirrels for woodlands within reserves and buffer zones. Woodland management grant payments for Cumbria list one grant of £797 and nine grants with a total of £97,171 for Northumberland. Note that these figures include grants awarded but not paid out yet.

5.2.3 Data

Squirrel records are stored digitally (Excel spreadsheets) and shared with other squirrel organisations through regular emails. Data, e.g. squirrel records in Northumberland by FC staff, are also mapped for the Kielder Forest and the map is updated quarterly.

5.2.4 Awareness raising

FC is active in raising awareness for the red squirrels through talks (e.g. as part of presentations to schools), guided forest walks, the provision of leaflets and other material and *ad hoc* radio and TV interviews as well as articles in the press. Forestry Commission also hosts a website (www.forestry.gov.uk) with information, e.g. on the designated reserves, grants, habitat management, walks, and species information. FC also provides Practice Notes on red squirrel conservation, squirrel monitoring and grey squirrel management (www.forestry.gov.uk/publications).

5.3 RED SQUIRREL PROTECTION PARTNERSHIP (RSPP)

The Red Squirrel Protection Partnership (RSPP) was formed in 2006 and its Chairman is Lord Redesdale. It operates throughout the whole of Northumberland and in parts of Durham. Funding has been provided by grants from central government and regional organisations supplemented by membership fees, donations and sponsorship. In June 2006, RSPP was awarded a grant of £148,000 over three years by Defra under the Rural Enterprise Scheme. This funding was conditional on a number of project milestones being set, primarily the recruitment of volunteers (500 by July 2008, 1,000 by July 2009) and an area of land 'signed up to project' (200,000 acres [81,000 ha] by July 2008). An additional £18,000 was raised from private sources. RSPP has one full-time trapper and two part-time shooters. Additionally, volunteers have been recruited who report squirrel sightings on their land and allow traps to be set and

inspected by the trapper, or who control the squirrels themselves. These arrangements are formalised in a signed agreement between each volunteer and RSPP.

5.3.1 Control of grey squirrels

The main method of control is live-trapping using a single-catch trap. Each trapped squirrel is transferred to another trap and taken a short distance away from the original capture site before being despatched by shooting in the head. This avoids the first trap becoming contaminated with blood when the squirrel is shot. Free-ranging squirrels are also shot on the ground or in the drey. Recently, RSPP has begun deploying kill-traps (Fenn MkIV), which are set inside wooden boxes. Each box, which may be fixed to the trunk of a tree or set on the ground, contains one kill-trap and is usually baited.

RSPP carries out control in any habitat where grey squirrels live and states that it is instigated in response to public sightings, systematic survey work or as part of an on-going programme. The intention is to completely eradicate grey squirrels from Northumberland and to achieve this control is continuous (i.e. all year) and will be carried on indefinitely if funds are available. However, no surveys have been carried out before, during or after control to evaluate success, although it was considered that eradication (at least locally) had been achieved. The annual cost of control was estimated to be £50,000.

5.3.2 Habitat management

The RSPP is not involved in habitat management.

5.3.3 Data

Records of grey squirrel kills are stored in an Excel workbook in which each worksheet lists the number of squirrels killed in a particular month against the name of the person reporting kills and an address where the culling occurred. The first kill was recorded on 10 Feb 2007 and by 30 Sep 2008 the number of squirrels killed had risen to 20,157. However, RSPP indicated that sometimes kills attributed to a particular month were in fact kills over a much longer period (e.g. over the previous 12 months). Reported sightings of red and grey squirrels are also stored on a spreadsheet. There are no data on trapping/shooting effort (i.e. number of trap nights, number of shooting days).

5.3.4 Awareness raising

RSPP is not involved proactively in education, raising public awareness or research. However, the organisation maintains a website containing information about red and grey squirrels. People visiting the site are encouraged to become members, report sightings of red and grey squirrels, or to volunteer to control grey squirrels themselves after receiving appropriate training. The website contains a map showing the approximate location of all grey squirrels that have been killed by RSPP operatives and volunteers.

5.4 LOCAL GROUPS (NORTHERN RED SQUIRRELS)

Northern Red Squirrels is an independent umbrella group whose stated aim (www.northernredsquirrels.co.uk) is to unite and promote voluntary red squirrel conservation across Northern Britain. It currently comprises 45 regional groups in Cumbria and Northumberland.

5.4.1 Control of grey squirrels

The main focus of the groups appeared to be grey squirrel control but some like the Westmoreland Red Squirrel Society have started a red squirrel breeding programme. Methods of despatch vary and involve shooting and trapping. Cage-trapped squirrels are despatched by the 'Sack' method, shooting or by running them into a Kania trap. On some occasions lethal injection (administered by a vet) has also been used (see also Section 8). Control is carried out as part of an ongoing programme as well as in response to public sightings. Not all groups have given an indication of costs of control carried out and in many cases time is given for free or control is paid for by the dedicated individuals. Where estimates have been provided, they range from £200 to >£2,000 a year.

5.4.2 Habitat management

Some members carry out habitat management (e.g. in the Yorkshire dales at Widdale) measures including the planting of conifers to improve red squirrel food supply and the planting of small seeded broadleaves in preference to large seeded ones.

However, group representatives also expressed the view that given the focus on conifer planting, habitat management for red squirrels outside reserves is detrimental to the natural diversity of British woodland and should therefore not be encouraged.

Habitat management is not necessary in most rural and urban areas to sustain red squirrel populations, as long as there are no greys.

5.4.3 Data

Data recording varies between groups with regard to what details are stored, but include recorder details, date, squirrel species, age, sex and details of despatch for grey squirrels (e.g. shot, trapped, road kill etc.). Some groups make use of recording forms provided by SOS (e.g. Berwick group) and others use their own format.

5.4.4 Awareness raising

Northern Red Squirrels host a website with the stated objective "to promote communication and collaboration amongst the various member groups, as well as providing resources which may help the various disparate member groups to pursue their common conservation tasks". NRS also produce a quarterly newsletter.

Different groups also hand out leaflets, print posters, give presentations and hold fund raising events. Information provided indicates that groups are self-funded and raise money through events and donations by members of the public. Spending on raising awareness varies between groups, and figures provided range between £20-£170.

5.5 CENTRE PARCS

Centre Parcs runs a holiday village within the designated red squirrel reserve of Whinfell Forest near Penrith, Cumbria. The habitat at Whinfell is managed for red squirrels and they are seen as an important visitor attraction at the site. As a result, the organisation employs a full-time grey squirrel control operative to safeguard the local population of red squirrels.

The area covered includes the reserve and the designated three-mile buffer zone around the reserve. In addition, the operative has developed a network of volunteers in the wider area that report sightings and in some cases carry out grey squirrel control.

5.5.1 Control of grey squirrels

Animals are caught in single-capture traps and despatched using the 'Sack' method as well as by shooting in the trap and by shooting individuals on the ground. Centre Parcs states that control operations are carried out as part of an on-going routine programme of control (monthly and quarterly) and in response to public sightings and a systematic monitoring survey. Surveys in an area are also carried out during control operations (casual sightings). There is no monitoring post control.

The reported perception is that the control is effective in achieving the aims of red squirrel conservation. A number of sightings of greys within the buffer zone and reserve are now considered the result of continued immigration only and that they are mainly from the edge of the zone. The perception was that the network of landowners, and volunteers, backed by the control operative, is keeping the reserve and buffer zone under control; and if resources could be found for more control operatives, there was a desire to now move outside the buffer zone and control grey squirrels in a wider area. However, a written internal report analysing Centre Parcs grey control data (Waller 2008) does warn that whilst the numbers of grey squirrel reports since 2005 that require attention and control have risen considerably, the resources for this have not. It concluded that there was a need to reassess resources, particularly with regard to the spring dispersal period when immigration can be high.

5.5.2 Habitat management

Habitat management of the area is agreed with the landowner. The wider reserve area is not under Centre Parcs control but managed by Lowther Estate. Management includes the felling of broadleaved tree species and the avoidance of thinning or harvesting operations while red squirrels are breeding. Furthermore, no large seeded-broadleaf species will be planted.

5.5.3 Data

Centre Parcs staff carry out regular red squirrel monitoring (visual transects) to estimate the red squirrel population. Casual sightings are also collated for each transect and both assist with grey squirrel control. Data for both the red squirrel monitoring and grey squirrel sightings are stored digitally on Excel spreadsheets and have been made available on request (e.g. to Newcastle University in 2005 and currently as part of the red squirrel review). Data on grey squirrel control are also stored digitally and record date, location, who reported it, sex and whether the animal was shot or trapped and if a blood sample was taken.

5.5.4 Awareness raising

Centre Parcs offers educational walks, gives presentations and provides materials for visitors and has been the focus or location for several radio and TV events over the last few years.

5.6 WILDLIFE ARK TRUST (WAT)

The WAT is a registered charity committed to the conservation of two charismatic and endangered native mammals: the red squirrel and the water vole *Arvicola*

terrestris. The WAT is in favour of any conservation measure that will help red squirrels including the control of alien pest species. Activities revealed by the questionnaire include financial support of grey squirrel control groups, raising the funding for the development of a squirrelpox vaccine and funding of a genomic sequence project on SQPV.

5.6.1 Awareness raising and research funding

WAT hosts a website (www.wildlifetrust.org) and raises awareness for red squirrel conservation. It also supports research for red squirrel conservation and has raised >£300,000 to pay for the first 2.25 years of a costed vaccine research project at the Moredun Institute in Scotland. In addition, WAT spent £5,000 on the genomic sequence project at Liverpool University.

The feasibility of a vaccine for red squirrels is an important development in the accepted strategy for red squirrel conservation. The WAT is seeking public financial support to raise the money for the currently unfunded nine months of research of the three-year vaccine feasibility study. All funds raised to date have been from non-public sources such as dedicated private individuals.

5.7 UNITED UTILITIES

United Utilities manages the reservoir and surrounding woodland of Thirlmere, a designated squirrel reserve. Squirrel management at the site involves grey squirrel control and habitat management. There is no public awareness or education work but the reserve has a hide for viewing red squirrels as a visitor attraction.

5.7.1 Control of grey squirrels

Grey squirrels are controlled for red squirrel conservation with the aim of removing all grey squirrels from the squirrel reserve to prevent disease transmission. They are trapped and euthanized using either the 'Sack' method or by shooting them in the trap. Free-running squirrels are also shot. Control is carried out in response to public sightings and as part of a routine programme on a monthly basis.

Monitoring (casual sightings) in control areas is carried out before and during control. A series of squirrel feeders is also used to detect the arrival of grey squirrels.

Work is carried out by a part-time control operative and volunteers. United Utilities is in receipt of a woodland grant for the grey squirrel control.

5.7.2 Habitat management

No information on habitat management was given. However, Thirlmere was mentioned in the press (e.g. Guardian April 16, 2007) for the felling of non-native conifers along the A591 and replacing them with native broadleaves.

5.7.3 Comments

The conveyed impression is that there is currently only a low number of grey squirrel sightings and that grey squirrels are under control. However, there is concern about SQPV disease outbreaks. Paid control operatives are seen as the key with regard to grey control and the future.

5.8 YORKSHIRE DALES NATIONAL PARK AUTHORITY (YDNPA)

YDNPA carries out habitat management for red squirrels, grey control and public awareness work. Grey squirrels are controlled for red squirrel conservation.

5.8.1 Control of grey squirrels

Grey squirrel control follows best practice advice from the Forestry Commission and is carried out on YDNPA property. The aims are to remove all grey squirrels, if possible, and reduce the risk of SQPV transmission. Control is carried out by a contractor on a quarterly basis at a cost of c.£500, paid for by YDNPA. Volunteers using hair-tubes carry out monitoring before and during control. YDNPA also runs a small trap loan scheme with appropriate training for residents and landowners in the Hawes area.

It is important to note, that in terms of grey squirrel control, in the Yorkshire Dales virtually all woodlands in the buffer areas are under 2ha with many under 1ha. In many cases, a number of different landowners may own part of the wood. As most of the smaller woods are only eligible for Environmental Stewardship, there is no funding available through these schemes that will fund grey squirrel control. Even for woodlands eligible for Forestry Commission grants, the small size and multiple ownership means that an area-based payment will not be sufficient to fund adequate grey squirrel control. It should be noted that for most of the larger red squirrel reserve woodlands in the Dales where an appropriate level of grant aid would be available, there are no grey squirrels.

YDNPA owns Freeholders' Wood, a SSSI hazel coppice woodland near Aysgarth c.12km to the east of the Widdale reserve buffer zone. Freeholders' Wood is one of the nearest woodlands to the buffer area and will support a high number of grey squirrels. It is felt that control there would help reduce the number of (presumably) juveniles dispersing towards the buffer and reserve area. The location of the wood highlights the need in some areas for a wider engagement with regard to grey control outside buffer zones.

5.8.2 Habitat management

The Forestry Commission consults YDNPA on applications for felling licences and new or replanting schemes in the YDNP. This gives both organisations opportunity to include, or discuss with woodland owners or managers the generic management guidelines for red squirrel reserves or buffer areas in any felling or planting schemes. Advice given follows generic FC guidelines (see also Appendices 5 and 6).

5.8.3 Data

Data from the monitoring are published in an annual report and stored digitally (Excel).

5.8.4 Awareness raising

YDNPA provides leaflets and information on its website. Its staff also give talks to local community and wildlife groups. The hair-tube monitoring programme undertaken by full-time YDNPA staff and volunteers in reserves and surrounding buffer zones is also used to raise awareness. Funding for this is covered by existing staff time.

5.9 FORD & ETAL ESTATES

Ford & Etal is a relatively large estate (~6,000 ha) of mixed woodland and agriculture that straddles the boundaries between the English and the Scottish efforts to conserve red squirrels (and control grey squirrels). The estate carries out grey squirrel control, habitat management for red squirrels and public awareness and education work. The estate also provides training for grey squirrel control.

5.9.1 Control of grey squirrels

Grey squirrels are shot or live-trapped; those trapped are despatched by the 'Sack' method or shooting. Control is carried out as part of a routine, continuous programme carried out by two part-time operatives. The aim of the control is to remove grey squirrels and to prevent SQPV transmission. The estate states that grey squirrels are monitored systematically; casual sightings are also recorded; monitoring is carried out before, during and after control. Records are forwarded to SOS. Annual costs are estimated at £5k and funded by the estate.

5.9.2 Habitat management

Habitat is managed for red squirrels in woodland within the buffer zone of a designated reserve and includes the avoidance of felling or thinning during the red squirrel breeding period.

5.10 PEOPLES TRUST FOR ENDANGERED SPECIES (PTES)

The PTES is a conservation charity created in 1977 to ensure a future for endangered species throughout the world.

5.10.1 Research and conservation project funding

It currently supports SOS with 15k, a research project on adenovirus by the VLA and work on red squirrel diseases by Tony Sainsbury, Zoological Society of London.

5.10.2 Comments

The PTES would appreciate more co-ordination in the north-east and suggested the setting up of a specialist Google Group for all organisations and volunteers to improve communication.

5.11 CONSERVATION EFFORTS AND VIEWS IN SCOTLAND

As part of the current review, information was collated from Scottish National Heritage (SNH), Red Squirrels in South Scotland (RSSS), Scottish Wildlife Trust (SWT), James Pringle and the Forestry Commission in Scotland.

5.11.1 Red Squirrels in South Scotland (RSSS)

The current conservation effort in the Scottish Borders considers the incursion by pox carrying grey squirrels from northern England as the single greatest threat to red squirrels. Project proposals by RSSS (R. Wales pers. comm.) further suggest that "the south of Scotland is now the frontline in the defence of the country's remaining red squirrel population". It is thought that inaction will lead to the rapid spread of SQPV and the extinction of the red squirrel population in south Scotland. It will also speed up transmission of the virus to uninfected grey squirrels in the Central Belt and thereafter to both squirrel species throughout the rest of the Scottish mainland. Antibody testing in grey squirrels shows that >58% of individuals are seropositive (RSSS Phase IV Project Proposal 2008). Furthermore, a seropositive grey squirrel

caught in the Kelso area (22nd May 2008) indicates disease spread to the south-east of Scotland and from there, in the near future, back into north Northumberland (authors' comments).

The main focus of RSSS efforts will be to:

- Stop the spread of the squirrelpox virus in south Scotland.
- Demonstrate the increase in the control network of land managers and volunteers.
- Reconnect the wider public with the red squirrel in Scotland by promoting and communicating the key messages.

5.11.2 Forestry Commission Scotland (FCS)

FCS is leading the selection of 'red squirrel strongholds' – a suite of sites which will be managed to provide a refuge for red squirrels should greys eventually spread further into Scotland. In strongholds, management actions will be promoted which improve the habitat for red squirrels and decrease the site's attractiveness to grey squirrels. The aim is to give red squirrels a differential advantage over greys in these sites.

A list of large, conifer-dominated candidate sites has been selected using GIS-based analysis, and informal consultations are proceeding to select the best 20 or so of these sites (some 80,000 ha in total). The final suite of sites is due to be published within an overall red squirrel conservation strategy in early 2009.

6. RED AND GREY SQUIRREL DISTRIBUTION

6.1 SQUIRREL RECORDS AND DISTRIBUTION MAPS

Red and grey squirrel sightings, grey squirrel control data and locations of management grants were obtained from FC, RSPP, Centre Parcs, SOS and some NRS groups. The data were imported into the GRASS GIS system and used to create distribution maps and where possible maps to indicate where grey squirrel control was carried out. The grey squirrel sightings data were divided into north-east and north-west based on easting and northing and split into five 6-monthly time periods (Table 6.1).

Table 6.1 Six-monthly time periods for red and grey squirrel sightings

Period 1	July 2006-December 2006
Period 2	January 2007 to June 2007
Period 3	July 2007 to December 2007
Period 4	January 2008 to June 2008
Period 5	July 2008 to December 2008*

*note that data available for the current review go only to November 2008 and period 5 is therefore an underestimate of grey squirrel sightings compared to other periods

The red squirrel data (Figs. 6.1 to 6.5) suggest still healthy populations in the north of England across Cumbria and Northumberland. Red squirrels are still widespread. There is also an apparent increase in red squirrel sightings, especially in designated reserves in 2007, 2008. Nevertheless, there are relatively few red squirrel records within some of the reserves and buffer zones. This is most likely indicative of a lack of a consistent and comprehensive monitoring programme for the squirrel reserves rather than an absence of red squirrel populations.

The grey squirrel distribution maps clearly show that reported sightings cover most of Northumberland and Cumbria with high and consistent concentrations of sightings in south Northumberland and Tyne and Wear. The absence of sightings in County Durham is most likely due to the area being outside the SOS remit or a lack of recorder effort rather than present grey squirrel populations. Grey squirrels are certainly present there.

There is no obvious change in the distribution of grey squirrels in south Northumberland across the five time periods. There are, however, noticeably fewer grey squirrel records along the North Tyne valley and south and eastern edge of the Kielder Forest buffer zone between Periods 2 & 3 and Periods 4 & 5.

For grey squirrel control on a regional scale to be successful, it would have to be effective in significantly reducing and removing local grey squirrel populations and it would have to be comprehensive i.e. cover the area systematically without gaps (C. Shuttleworth pers. comm.).

A plot of RSPP cull locations (all years combined) with grey squirrel sightings for Period 5 only (Fig. 6.6) illustrates that grey control efforts at the landscape level are currently insufficient for a regional, large scale control and conservation effort.

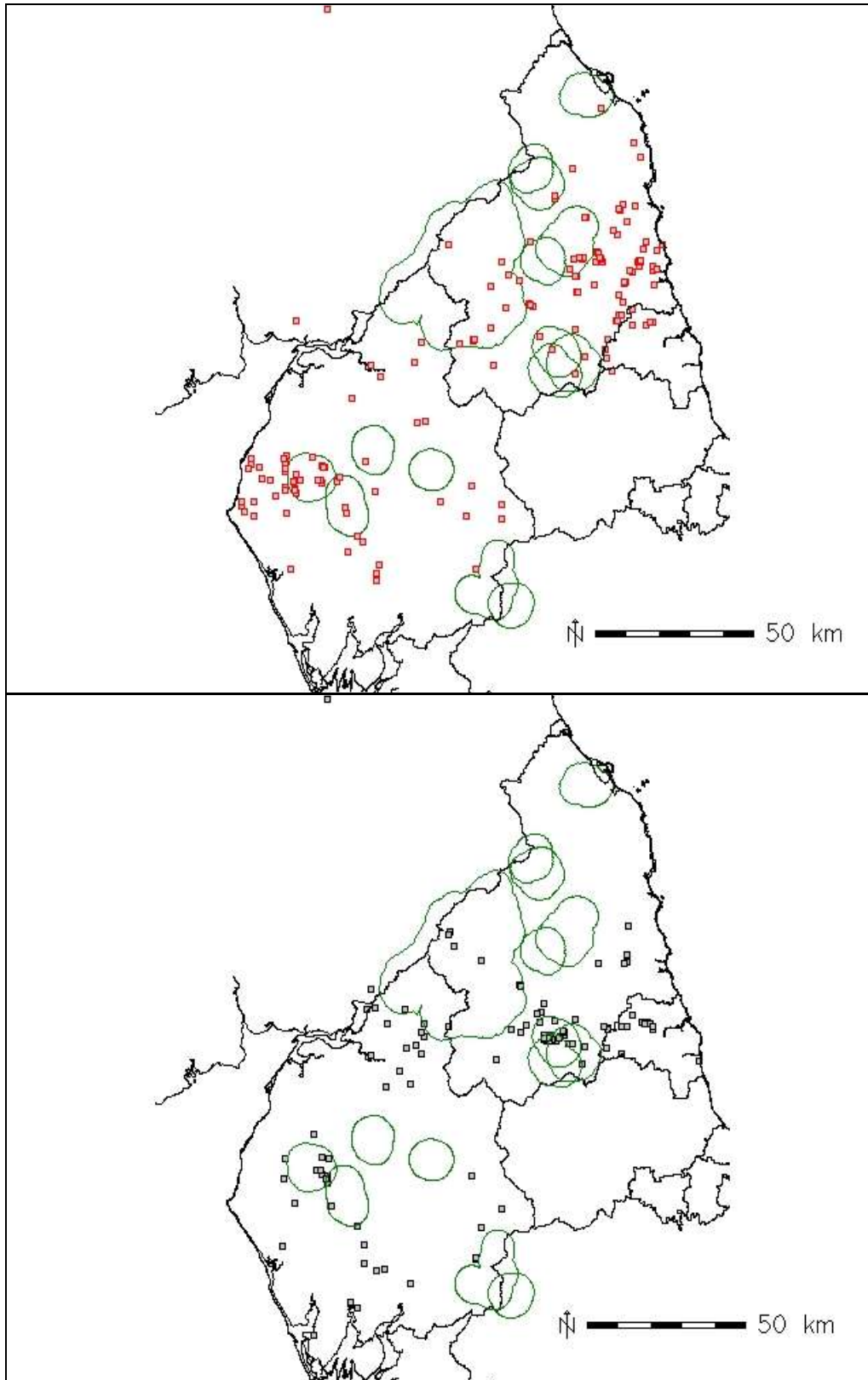


Figure 6.1 Red (top) and grey (bottom) squirrel sightings in the north of England for Period 1: July 2006-December 2006. Green outlines represent the boundaries of the designated reserve buffer zones.

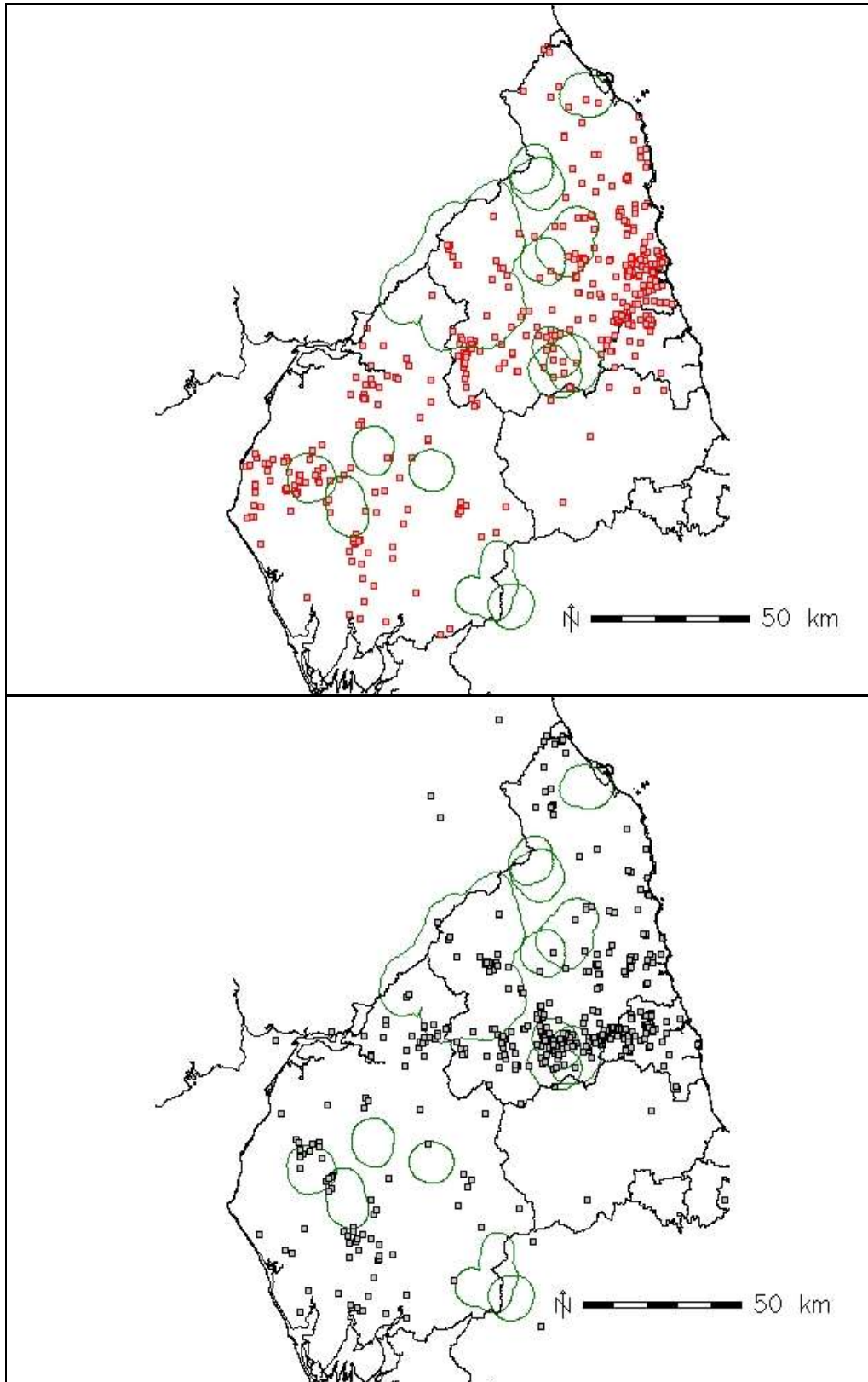


Figure 6.2 Red (top) and grey (bottom) squirrel sightings in the north of England for Period 2: January 2007 to June 2007. Green outlines represent the boundaries of the designated reserve buffer zones.

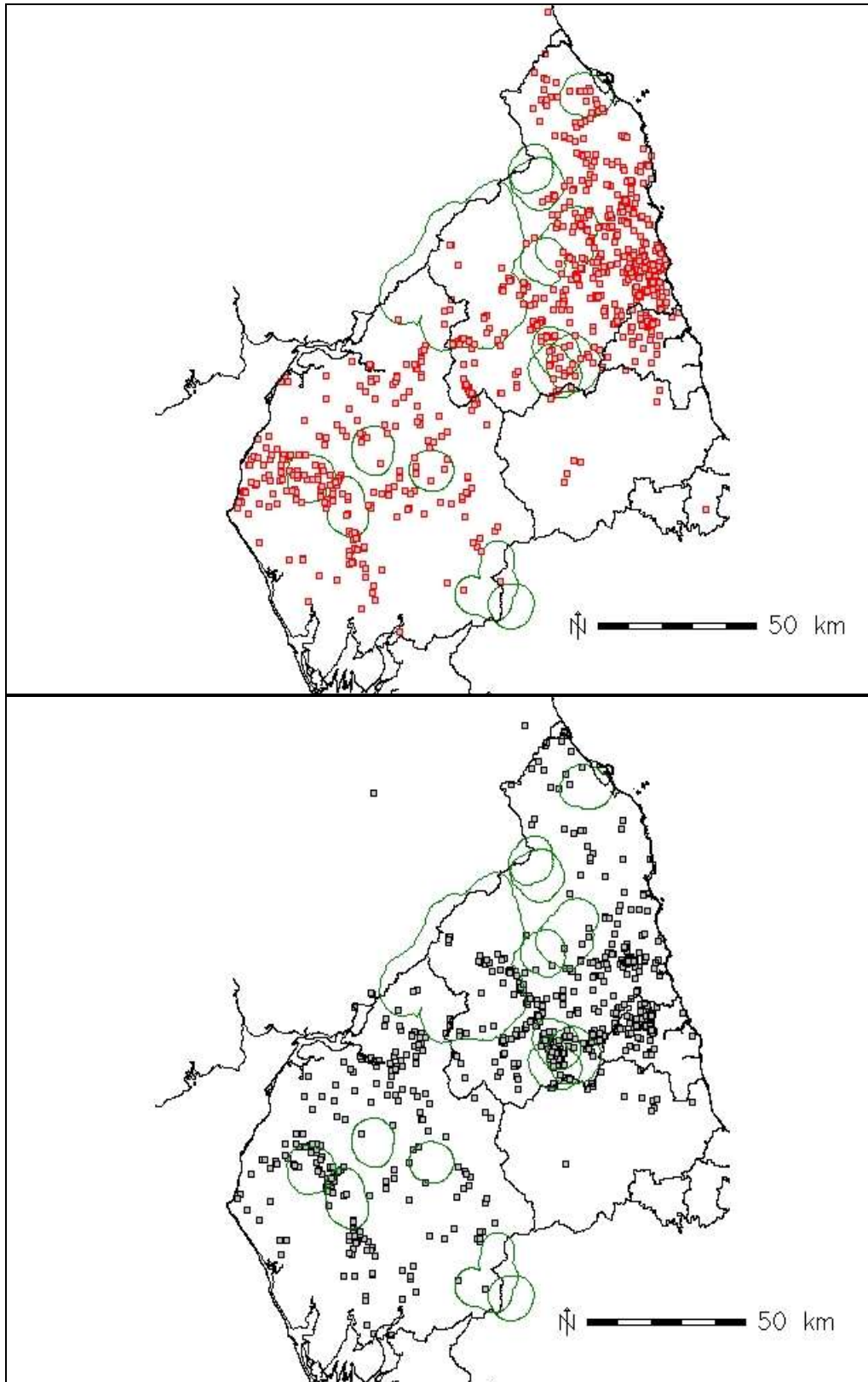


Figure 6.3 Red (top) and grey (bottom) squirrel sightings in the north of England for Period 3: July 2007 to December 2007. Green outlines represent the boundaries of the designated reserve buffer zones.

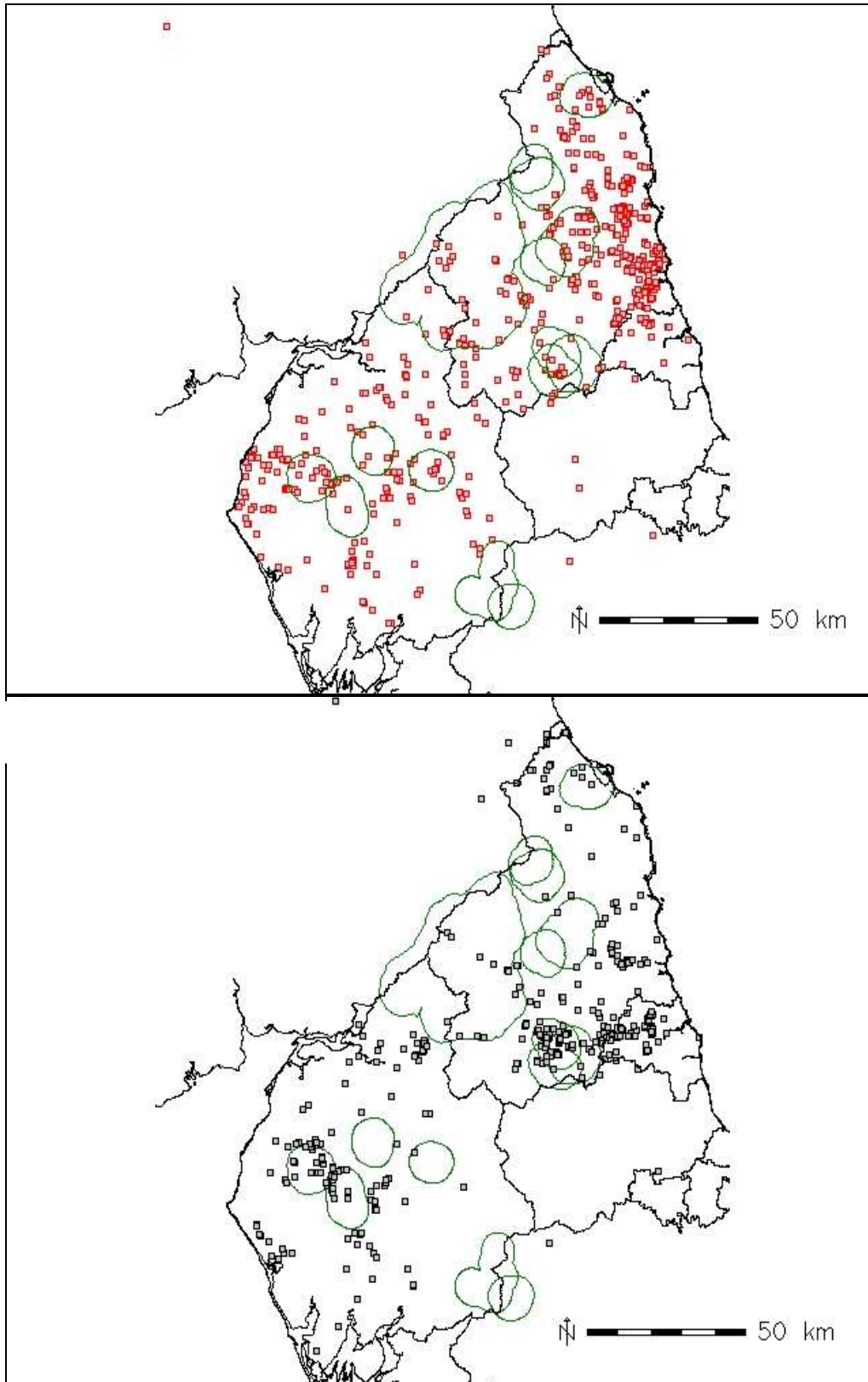


Figure 6.4 Red (top) and grey (bottom) squirrel sightings in the north of England for Period 4: January 2008-June 2008. Green outlines represent the boundaries of the designated reserve buffer zones.

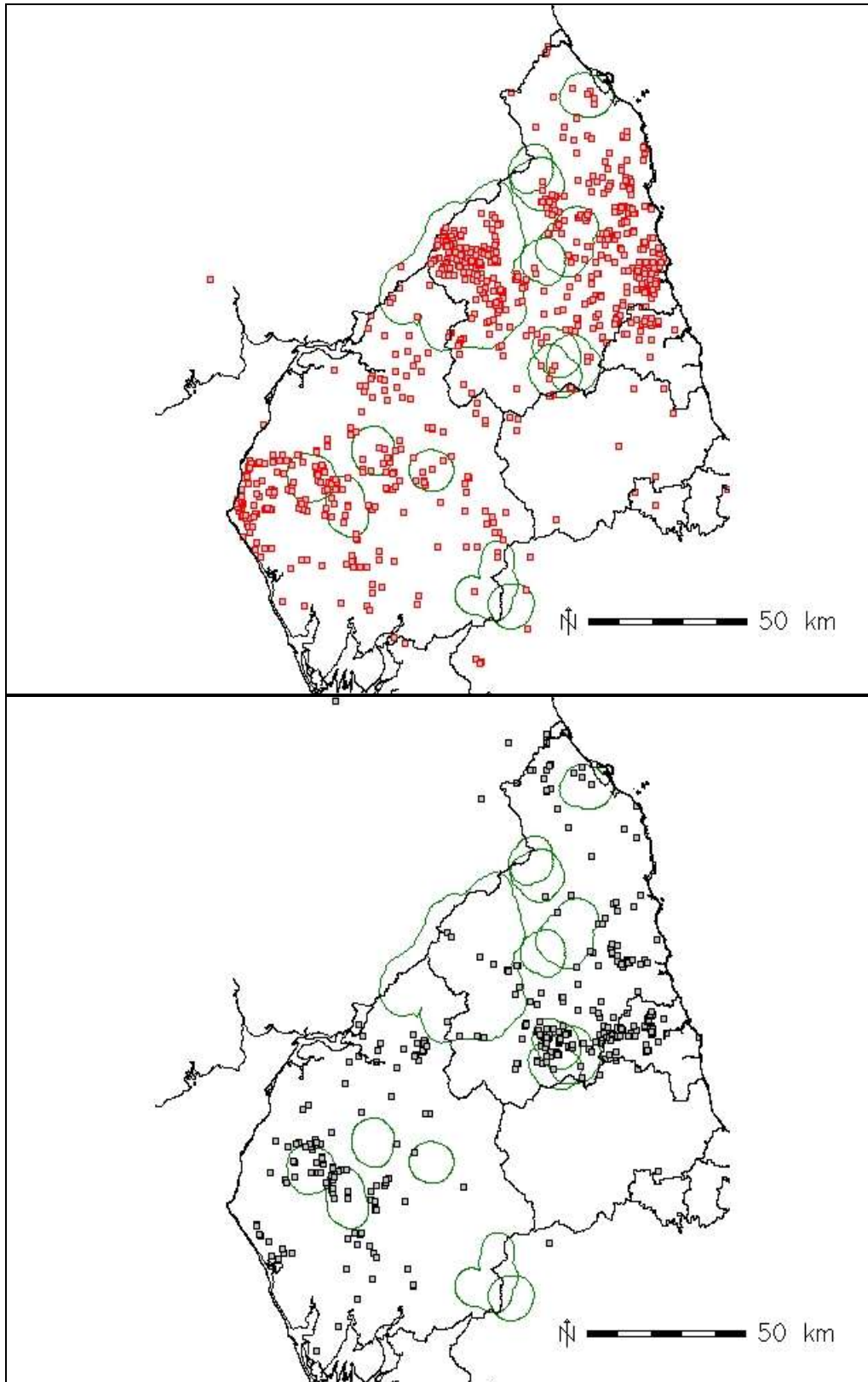


Figure 6.5 Red (top) and grey (bottom) squirrel sightings in the north of England for Period 5: July 2008-November 2008. Green outlines represent the boundaries of the designated reserve buffer zones.

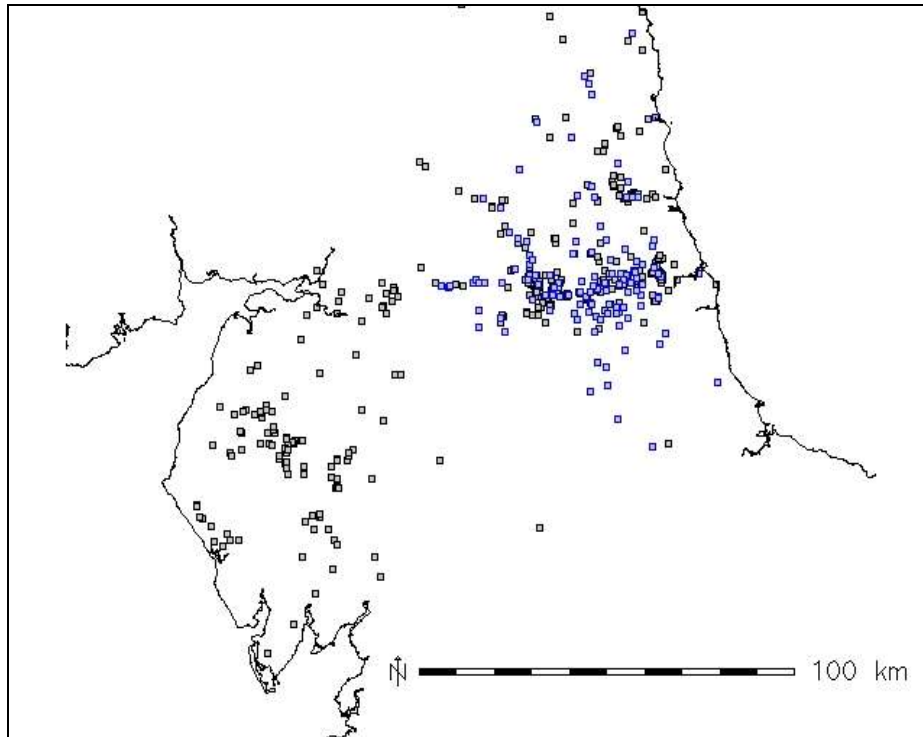


Figure 6.6 RSPP cull locations (all years combined in blue) overlaid with grey squirrel records (in grey) for Period 5 only.

Furthermore, grey squirrel records for each of the five 6-monthly periods in the north-east and north-west indicates that the pattern of submitted public sightings is the same for both regions. That is, increasing from period 1 to Period 3 and then decreasing to Period 5. For the purpose of analysis the records were split by the ‘eastings’ and split into west and east. The north-west is the bigger area and this would explain the consistently larger number of records (Fig. 6.7).

Figure 6.7 shows the proportion of records (NE/NW) as a trend line. If grey squirrel control in the north-east was effective and had reached a situation where grey squirrels had been significantly reduced or eradicated from large areas, then one would expect the line to show a downward trend. This is not the case (see also distribution maps Fig. 6.1-6.5). The data actually show a relative increase for Period 5 suggesting that either recording effort was disproportionately lower in the north-west compared to the north-east for Periods 4 and 5; or that there has been no detectable decline in the distribution of grey squirrels in the north-east. Interviews with SOS staff regarding the call for records during Period 5 did not suggest any difference in effort for collecting records in both regions. Overall, the maps indicate a consistent level of reported grey squirrel sightings with a peak for 2007 in both regions.

A spatial analysis of cull locations for RSPP (all years combined) in relation to grey squirrel sightings (Period 5 only; Figure 6.6) clearly shows that control effort in terms of cull locations does not cover all areas from where grey squirrels are reported. When awarded FC grey squirrel control grants are mapped together with control efforts by SOS and RSPP (Fig. 6.8) it is apparent that FC and SOS focus on reserves and buffer zones whereas RSPP cull locations are targeted predominantly at south Northumberland.

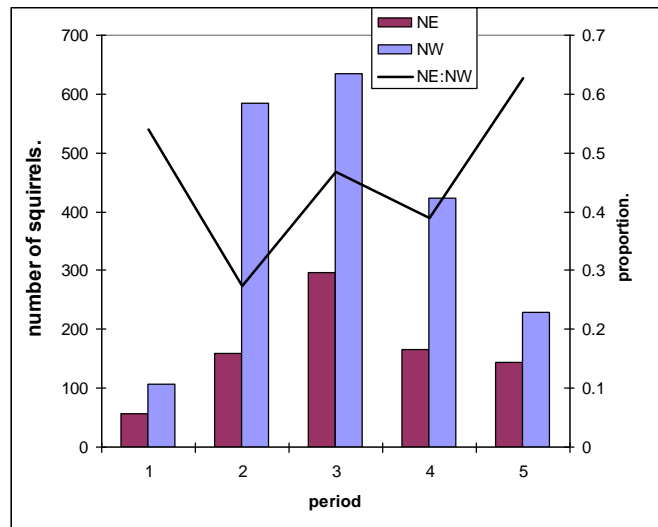


Figure 6.7 Bar chart of grey squirrel sightings for the north-east and north-west. The relative proportion of records (NE/NW) is shown with a black line.

Figure 6.8 plots the central locations for Forestry Commission grant schemes (WIG), the locations for grey squirrel control carried out by SOS and RSPP. The figure illustrates that control effort for grey squirrels is not joined-up, RSPP is essentially pursuing a regional grey squirrel control strategy whilst SOS and the Forestry Commission follow the UKRSG backed reserve-based strategy.

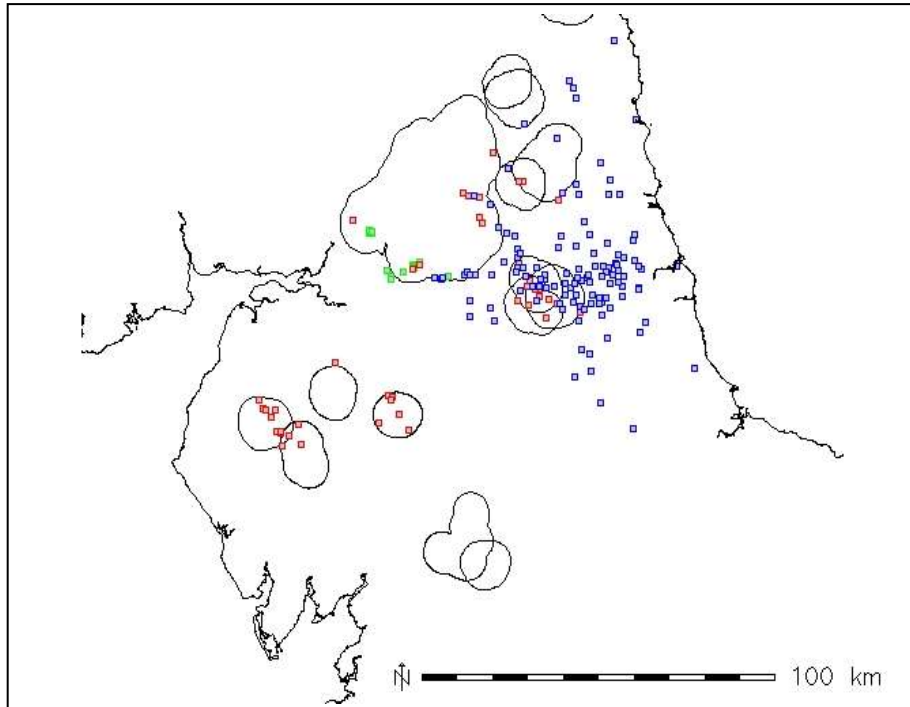


Figure 6.8 The location of awarded or approved management grants by Forestry Commission (WIG-AMG) in red; grey squirrel cull locations from the SOS control operative in Cumbria in green and RSPP grey squirrel cull locations (all years combined) in blue.

It should be noted that grey squirrel control is also carried out by NRS groups, Centre Parc and landowners but are not shown here - digitising and verifying these organisations paper records or allocating grid references to named locations went beyond the time frame of the current review. However, future grey control recording should be standardised, include grid locations and be stored digitally in order to assess the spatial coverage of efforts (see also Section 10 Data Collation).

6.2 CONCLUSIONS

- The relative proportion of recorded grey squirrel sightings in the north-east compared to north-west has increased rather than declined suggesting that grey squirrel control in the north-east has not affected grey squirrel immigration rates.
- Map data indicate that there are areas with grey squirrel sightings that are not controlled.
- Map data show no decline in grey squirrel sightings in the north-east; the data analysed suggest an increase rather than a decrease of reported squirrel sightings for north-east.
- Red squirrel distribution is still widespread in the North of England.
- Red squirrel monitoring or the recording of sightings has gaps, especially with regard to squirrel reserves.
- Data on control locations from SOS and RSPP as well as Forestry Commission grant schemes for grey control clearly show that different strategies are pursued by SOS, FC and RSPP respectively.

7. REVIEW AND EVALUATION OF CURRENT OVERALL STRATEGY

The various red squirrel conservation organisations differ in their organisational and funding structures and their respective conservation projects vary in their approaches and criteria of success. Consequently, it is very difficult to directly compare their relative effectiveness. Therefore, the effectiveness of individual organisations has been evaluated against the degree to which their respective defined aims and objectives had been achieved.

This section evaluates the overall organisational strategies and their efforts in the principal areas of conservation activity, and provides suggestions to improve current efforts and recommendations for the future direction of red squirrel conservation efforts. Overall, there are three main problems that are currently impacting on red squirrel conservation work in northern England: lack of funding to support the reserve strategy especially with regard to systematic grey squirrel control, a fragmentation of effort with a lack of a joined-up, co-ordinated strategic direction and open public disagreement between ‘official’ organisations such as SOS and RSPP.

Irrespective of specific recommendations, the priority and first fundamental step, with leadership from the statutory agencies, must be to renew efforts to agree a co-ordinated strategy with all willing organisations and voluntary squirrel groups across the North of England, with a strong link to red squirrel conservation efforts in Scotland.

7.1 ORGANISATIONAL STRATEGIES

Although the overall objectives of the four main conservation organisations are to deliver red squirrel conservation, they differ in their approaches towards achieving this. The SOS campaign proposed a combined approach of implementation of conservation regimes around sixteen (now seventeen) designated red squirrel reserves, community engagement and development of sustainable skills and funding streams. Forestry Commission, who own and manage some of the larger red squirrel reserves, also have a combined approach, involving undertaking and funding habitat management, carrying out grey squirrel control and engaging with the public in education and awareness raising activities. The Red Squirrel Protection Partnership’s strategy is the attempted removal of grey squirrels from Northumberland. Northern Red Squirrels, an umbrella organisation of voluntary groups (45 in Northumberland and Cumbria) conduct grey squirrel control and habitat management at the local scale to promote red squirrel conservation across Northern Britain. Although the individual aims and approaches of the organisations are well intentioned, efforts are fragmented and there is a necessity to deliver more strategic and coordinated red squirrel conservation measures.

A fundamental impediment in the approach by SOS has been an imbalance in the relative resources directed towards practical conservation measures and towards engagement and community development. This was a consequence of constraints associated with the initial funding source. This has resulted in the over-emphasis and over-delivery of engagement objectives to the detriment and under-delivery of on-the-ground objectives – where the majority of resources should be targeted. This is illustrated by a few examples. First, the project team includes only three Conservation Officers (responsible for on-the-ground conservation activities of which one is funded by Lancashire Wildlife Trust) and two and a half People & Wildlife Officers

(responsible for education and engagement activities). The interviews have indicated that conservation officers field telephone enquiries and are involved in public engagement activities such as manning stalls during shows. Second, the business plan lists 17 conservation outputs/activities compared to 47 access and engagement outputs/activities. Third, all access and engagement outputs/activities have numerical annual targets, whilst this holds for only one third of conservation outputs/activities. Although it is correct that conservation outputs are not easily quantifiable in all cases, some degree of quantification is necessary against which to measure targets and annual progress. For example, identifying and contacting all main buffer zone landowners/managers (and production of electronic maps) would appear to be a quantifiable and essential task. On the positive side, considering the targets the project set itself, it has clearly been successful with regard to raising public awareness and community engagement, and appears to have established a good infrastructure to collate and map squirrel sightings.

The Forestry Commission's overall strategy toward red squirrel conservation is constrained by finite resources and competing objectives in terms of timber production, amenity and conservation of other species or important habitats. This results in marked variation in its commitment to red squirrel conservation between different sites, for example in the resources allocated to the control of grey squirrels. Commitment appears to be greater in high profile red squirrel sites, such as Kielder, in comparison to other sites where the priority of grey squirrel control seems lower. Forestry Commission efforts have ensured some notable successes, such as Kielder Forest District and Whinlatter Forest. Interviews with local squirrel groups, however, suggest that they would like the FC to demonstrate greater commitment in some areas.

The Red Squirrel Protection Partnership's strategy to eradicate grey squirrels from Northumberland is unachievable with their current resources. The removal effort responds to (and tracks) reported sightings rather than removing greys in a systematic and coordinated manner. In the absence of the latter approach grey squirrels will not be removed from all areas and will recover in those areas in which numbers have been temporarily reduced. A number of lessons have been learned from the eradication campaign in Anglesey, including the necessity for systematic culling and recovering ground that has been trapped previously.

The recent launch of Northern Red Squirrels as an umbrella organisation for Local Groups has to be welcomed. Interviews and contributions by members of the different local squirrel groups indicated a strong desire to save and retain red squirrel populations locally across Cumbria and Northumberland and a strong commitment to grey squirrel control. Given the paucity of data and the fact that records were never collected in a manner to allow statistical analysis, it was not possible to evaluate the local success of control operations. Certainly on a regional level past and current efforts have not led to a decrease in grey squirrel spread in Cumbria or Northumberland. Funding of the different squirrel groups appears to be entirely based on the contributions and efforts of the volunteers and on local fund raising. Some groups work closely with SOS.

The different approaches of the organisations have led to a divergence in the philosophy and focus of the overall conservation strategy. This has been exacerbated by a number of factors and perceptions, such as the organisations' differing ethos,

personality clashes, and feelings of disenfranchisement from the planning and delivery that have led to dysfunction between the different organisations.

7.2 RESERVE-BASED STRATEGY

The documentation provided by the different organisations (e.g. SOS business plan, UKRSG minutes etc.) as well as the scientific literature on red squirrel conservation, provide an insight and rationale for the current reserve-based strategy.

The plan for the current strategy was based on science, the practicalities of available funding and a desire to target limited resources where they could have the best chance of success. For example, strategies based on large-scale (uncoordinated) regional control of grey squirrels have failed historically (see Background: overview of current strategy). The final designation of the specific reserves, however, clearly included decisions not principally based on science. For example, a field visit as part of this review has shown that Mallerstang has no substantial forest cover, and it was not clear why it had been included? For Sefton, the educational and public engagement potential and the level of local engagement were clearly more important than its vulnerability to grey squirrel immigration and SQPV outbreaks. In addition, there is a conservation conflict between rare dune habitat and the maintenance of artificial pine woodland for red squirrels. Similarly, Slaley is difficult to defend from grey squirrels with the reserve complex and buffer zone containing substantial areas of habitat suitable for greys; with a danger of limited resources being targeted there at the expense of more suitable reserves elsewhere.

There is, therefore, a need to examine the status of some reserves and to look at the potential of other possible sites. The recent inclusion of Greenfield was a step in the right direction as it increases the viability of the Dales reserves as a whole (see Habitat Management). There may be other areas with substantial red squirrel populations that merit inclusion in the reserves or some form of support and this should be examined.

7.3 ENGAGEMENT AND COORDINATION

There is a need for a wider engagement and broadening of conservation efforts and recognition of the role of voluntary groups and landowners. Until recently these volunteers have been the main focus for delivering grey control. Initial SOS funding restrictions with regard to grey control, meant in effect that this critical element of the conservation strategy was only supported by a small number of FC management grants, and by voluntary efforts and contributions of individuals and local squirrel groups. There is clearly an inherent tension in this situation both in terms of funding and in the desire of individuals and local groups to protect red squirrels locally or on a regional scale rather than in a potentially distant designated reserve.

Interviews with different organisations and voluntary squirrel groups in England and Scotland also highlighted the importance of more communication and a greater involvement and respect by SOS towards the other partners. Despite efforts by the steering committee and FC, there was a clear feeling that the implementation of the reserve-based strategy did not involve everybody in the decision-making process both in terms of the overall strategy and the original reserve selection. As recognised and acknowledged by SOS, the next phase of red squirrel conservation needs to be more inclusive.

7.4 SCOTLAND: CROSS-BORDER ISSUES AND CO-OPERATION

In Scotland, the recent direct involvement by the Minister and implicit government support in the campaign to conserve the red squirrel has brought about a coherent and cohesive squirrel policy. This kind of political support is clearly not present south of the Border.

The current Scottish strategy will employ a policy of grey squirrel control (carried out by control operatives) to prevent the spread of the virus together with the selection of key conservation sites (strongholds) across Scotland. In the absence of SQPV, even if greys spread throughout Scotland, strongholds would have a good chance of providing refuges for reds and giving them a chance to remain part of the UK's wildlife. With SQPV, site-based grey squirrel control will ultimately be needed to defend the reds in strongholds – and this has only limited chance of success. The most urgent priority for conserving red squirrels in mainland UK therefore is to prevent SQPV from spreading into Scotland. Grey squirrel control, targeted at pox incursion routes on both sides of the border, is the most important area for cross-border co-operation.

In addition, there is a need for consistent SQPV monitoring across North England, in order to estimate the prevalence and distribution of the disease, particularly in relation to outbreaks in red squirrels and dispersal routes across the border. This would help to underpin action in South Scotland, providing a reasonable estimate of where and how much grey control was required to prevent (not control) further spread of the disease.

There should be an increased commitment to grey squirrel control of animals spreading northwards from Cumbria. This would also support South Scotland deliver protection for Kielder as a north England reserve. Furthermore, grey squirrels should be controlled on the East side of Kielder to prevent dispersal of animals northwards.

7.5 RECOMMENDATIONS

- 7.5.1 Historically (uncoordinated) regional-strategies do not have a record of success and the current (but modified) reserve-based approach needs to be maintained.
- 7.5.2 If an eradication strategy is adopted with respect to a specific geographic area, it should be designed with clear deliverables and targets and reviewed annually.
- 7.5.3 The status of each designated reserve should be reviewed.
- 7.5.4 Following the above, other potential sites should be examined and selected as additional or alternative reserves.
- 7.5.5 Statutory agencies should take a lead and organise a squirrel forum to agree a joined up, co-ordinated strategy with all willing organisations and groups from the North of England.
- 7.5.6 Following the above, it is not sustainable to target limited public resources at organisations that do not work jointly towards a co-ordinated strategy, and that pursue fundamentally different objectives.

- 7.5.7 All elements of the overall strategy (grey control, conservation and engagement) must involve annual targets and reviews.
- 7.5.8 A future North of England strategy should coordinate grey squirrel control with Scotland.
- 7.5.9 There is a need for SOS to respect and credit the contributions and achievements of the other partners.
- 7.5.10 The strategy must recognise the role and dedication of, voluntary groups and landowners and widen engagement with them.
- 7.5.11 Paid control operatives should be used to target grey squirrels in the Solway area and the north-east in conjunction with Scottish efforts north of the border.
- 7.5.12 A cross-border SQPV monitoring scheme should be developed.

8. REVIEW AND EVALUATION OF GREY SQUIRREL CONTROL

8.1 SUMMARY OF QUESTIONNAIRE RETURNS.

Responses in the grey squirrel control section (B) of the questionnaire were analysed to determine what strategies and tactics have been employed to reduce the size of grey squirrel populations in northern England over the last three years. In total, 34 individuals responded (out of 40 who returned questionnaires) who were actively engaged in funding, organising or carrying out control. This non-random sample of all those carrying out control represented 9 organisations (Centre Parcs, CWT, Ford Estates, FC, NRS, RSPP, SOS, United Utilities, YDNPA). The responses provided qualitative, rather than quantitative, information about the methods that were used and the circumstances under which they were deployed. Some respondents did not answer all questions, thus in the tables below the base numbers for the percentages vary. The information was supplemented by face-to-face interviews and wherever possible by supporting data, such as the number of people participating in controlling greys, numbers of squirrels caught and the costs associated with control.

In summary, control was heavily dependent on the efforts of volunteers, either to carry out the trapping and despatching of squirrels, or to allow trapping to be carried out on their land (Table 8.1).

Table 8.1 Who carried out grey squirrel control.

	% of respondents (n=33)
Volunteer	82
Part-time operator	27
Full-time operator	12
Other (farmers, gamekeepers, contractors, etc)	12
Reserve warden	6
Forester	6

In October 2008, when interviews were carried out, there were only two full-time and one part-time trappers employed to control grey squirrels throughout the northern English counties (Lancashire, Merseyside, Cumbria, Northumberland, Durham and North Yorkshire). One trapper had only been in post for a few months. Respondents indicated that while control was often directed towards removing grey squirrels from buffer zones and the reserves, it was more likely to be conducted anywhere that a squirrel was sighted (Table 8.2) and initiated in response to members of the public reporting the presence of squirrels (Table 8.3).

Table 8.2 Where grey squirrels were controlled.

	% of respondents (n=31)
Anywhere that grey squirrels live	61
Reserve buffer zone	52
Designated red squirrel reserve	45
Other (nature reserve, urban gardens, incursion routes leading to reserves)	23
In relation to tree damage	3

Table 8.3 When grey squirrels were controlled.

	% of respondents (n=33)
In response to public sightings	91
Routine on-going control	79
Systematic survey work	27
Other (e.g. targeting potential incursion routes)	9

Overwhelmingly, the aim of control was to eradicate greys (Table 8.4), but respondents expected that control would continue indefinitely as long as funds were available. With few exceptions, trapping was carried out all year round and the cost of control varied widely from ‘nil’ (i.e. out of volunteers’ own pockets) to c.£50k per annum.

Table 8.4 Control objectives.

	% of respondents (n=34)
Eradicate grey squirrels	91
Control the spread of SQPV	88
Reduce the number of grey squirrels	59

Without sufficient funds to employ enough full-time operators to cover all the grey squirrel habitats in the northern English counties, trapping and shooting were heavily dependent on help from volunteers. Volunteers were enrolled into trap loan schemes, which operated in two different ways. Firstly, traps were loaned to volunteers who set them on their own property, or on land belonging to a friend or neighbour, and who despatched all grey squirrels that were caught. Organisations operating such a scheme offered advice and training on the correct placement and setting of traps and on humane killing techniques. Landowners with property inside the reserves or buffer zones could apply for funds from the Forestry Commission through the English Woodlands Grant Scheme (EWGS) to help with the costs of squirrel control. However, interviewees regarded the amount of money they would receive from that Scheme as too small to fund sustained control. In the second version of the trap loan scheme, landowners gave written permission for an operator to place traps on their property. The operator then set the traps and inspected them or relied on the owner to inform him when squirrels were caught.

Organisations operating the first type of scheme reported that there was very little feedback on how many squirrels were caught and during the interviews it became apparent that volunteers often passed on the traps to their friends without necessarily informing the original lender. The second type of scheme was more successful in that squirrel captures were more likely to be recorded, but in both types there was no recording of the effort (e.g. number of trap nights) that was put into trapping. Indeed, it was argued that funds were not available to collect and manage data on grey squirrel control, save for recording numbers caught. For perhaps the same reason, 44% (n=27) of respondents did no survey to determine how effective control had been while those that did a survey relied mainly on casual sightings.

Respondents reported that some landowners couldn't or wouldn't carry out control despite 'large' numbers of squirrels being present on their land. There was no opportunity to verify these reports, but their frequency suggested that efforts to eradicate grey squirrels were fragmentary and thus unlikely, in the long-term, to succeed. As few systematic surveys were conducted to evaluate whether control was working or had worked, success seemed to be judged on the numbers of grey squirrels killed and the reappearance of red squirrels after a period of absence. Indeed, the reappearance of red squirrels might be construed as indicating that grey squirrel control had been effective, at least in the short term. On Anglesey, Shuttleworth, (2004) showed that red squirrel numbers increased when grey squirrel populations were reduced by live-trapping. Overall, it was impossible to assess the temporal and spatial effects of control in terms of population trends over the last three years and changes in the distribution of grey squirrels: specifically, what areas, if any, are now grey squirrel-free (see Section 6).

8.2 METHODS USED TO CONTROL GREY SQUIRRELS

Live-trapping was the commonest method of controlling grey squirrels supplemented by shooting free-ranging squirrels on the ground or as they climbed up or down tree trunks (Table 8.5). Shooting was the preferred method of despatching cage-trapped squirrels. About half the respondents used the 'Sack' method, but opinion was clearly divided about its utility and humaneness: some thought it ought to be banned. However, it was often the only option if, for example, landowners would not permit use of firearms on their property. A few respondents have been experimenting with a Kania kill-trap, which they set and place at the entrance to the cage trap after a squirrel has been caught. The operator opens the trap door and encourages the squirrel to move into the kill-trap, where, it is claimed, the animal is killed efficiently and humanely. Some volunteers who train others to despatch squirrels now recommend this method in preference to other methods.

Table 8. 5 Methods used to control grey squirrels

	Despatch method	% of respondents
Live-trapped squirrels (n=27)	Shooting	81
	'Sack'	52
	Lethal injection	11
	Kill-trap	11
Free-ranging squirrels (n=26)	'Ground' shooting	77
	Drey shooting	19
	Kill-traps	4
	Other	0
Recommended to trainees in conjunction with live- trapping (n=20)	Shooting	95
	'Sack'	45
	Lethal injection	10
	Other	10

8.3 GWCT'S NATIONAL GAMEBAG CENSUS

The National Gamebag Census (NGC) was formally established by the Game & Wildlife Conservation Trust (GWCT), formerly the Game Conservancy Trust, in

1961. It is a voluntary scheme that currently collects bag statistics from over 600 shooting estates annually in England, Wales, Scotland and Northern Ireland. Through the inclusion of data from historical game books, series for several species extend back to the 19th century. The NGC statistics also include bags from rough shooting carried out on the same estates, as well as numbers of predatory species culled as part of legal pest control. At the end of the shooting season, each participant completes an annual bag survey form detailing the numbers of each species shot or culled, numbers of shoot days, estate area and, in the case of upland estates, moorland area. Reminders are issued for non-returned forms and the return rate exceeds 90%. The GCWT keeps the returns and the data they contain strictly confidential.

When expressed as the numbers of animals shot per unit area, the data provide temporal and regional trends in bags on shooting estates (Tapper 1992). Overall, the NGC collates data on the shooting bags of 24 huntable species and 19 predator species, including grey squirrel. All series are ongoing, with 2006 the last season of data collection (the year denotes the year in which a shooting season starts, e.g. 2006 refers to the 2006/07 season). The NGC Gamebag Census provides information on the ‘background’ level of grey squirrel culling that is carried out outside of that for red squirrel conservation purposes.

The grey squirrel cull data can be broken down by government office region (Figure 8.1), and trends examined over differing time-scales. The GWCT examined trends over time starting in 1961 (the formal start of the NGC) and 1995 (when the British Trust for Ornithology and many other members of the Tracking Mammals Partnership began their mammal monitoring schemes), and extending to 2006. The details of the statistical procedures are given in Appendix 7.



Figure 8.1 Government office regions of England

This procedure resulted in bag indices and confidence limits from the NGC data for the period 1961-2006. Bag indices were expressed relative to the first year of each period, so the index value for the first year of each series is always one. Analyses were carried out for the UK as a whole, at country level (England, Scotland, Wales), and by government office region (Figure 8.1).

In addition to overall national and regional grey squirrel control, game bags were compared between those estates lying inside red squirrel reserves and those lying outside. The comparison was restricted to the two latest years of data collection (2005/06 and 2006/07).

Results

Based on 799 sites across the UK, numbers of grey squirrels culled per unit area increased by 77% between 1961 and 2006 (Table 8.6, Fig. 8.2). The vast majority (85%) of sites were in England, so this change is essentially driven by the changes seen in England. Looking at government office regions in England, no significant change was observed in the south-east and north-west, but elsewhere there were significant increases, especially in the eastern half of the country. In Wales, there was no significant change over the 1961-2006 period. In Scotland, there were just nine reports of grey squirrel from six sites between 1961 and 1976. From 1977 to 2006, numbers of grey squirrels culled per unit area in Scotland tripled.

During the more recent period of 1995-2006, numbers of grey squirrels culled per unit area increased by roughly half in England, Wales and Scotland (42% over the UK as a whole). For English government regions, there was again no significant change in cull index in the south-east and north-west, but increases elsewhere were significant. They were highest in the north-east (175% increase), where too few grey squirrels had been trapped before 1995 for analysis of trend over a longer period.

Table 8.6 Sample sizes (number of sites contributing data at least twice between 1961 and 2006) and trends (percentage change, with 95% confidence limits) in numbers of grey squirrels culled per unit area during the period 1961-2006 in the UK, overall, by country and by government office region. In some cases, insufficient data prevented analysis starting in 1961; in these cases, the start year is given in italics. Data from GWCT's National Gamebag Census.

	Sites	1961-2006		1995-2006	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	799	77*	32 to 140	42*	25 to 63
COUNTRIES					
England	680	78*	33 to 145	40*	27 to 57
Wales	33	17	-51 to 318	78*	11 to 161
Scotland	<i>1977</i> 79	218*	33 to 591	50*	9 to 97
GOVERNMENT REGIONS					
South West	135	91*	17 to 190	62*	27 to 117
South East	141	-32	-55 to 1	12	-10 to 40
East of England	141	322*	155 to 556	37*	14 to 67
East Midlands	70	188*	63 to 430	70*	10 to 167
West Midlands	72	98*	11 to 235	100*	35 to 181
North West	<i>1984</i> 20	43	-33 to 368	2	-17 to 60
Yorkshire and Humber	85	247*	152 to 612	57*	24 to 90
North East	<i>1995</i> 12			175*	29 to 439

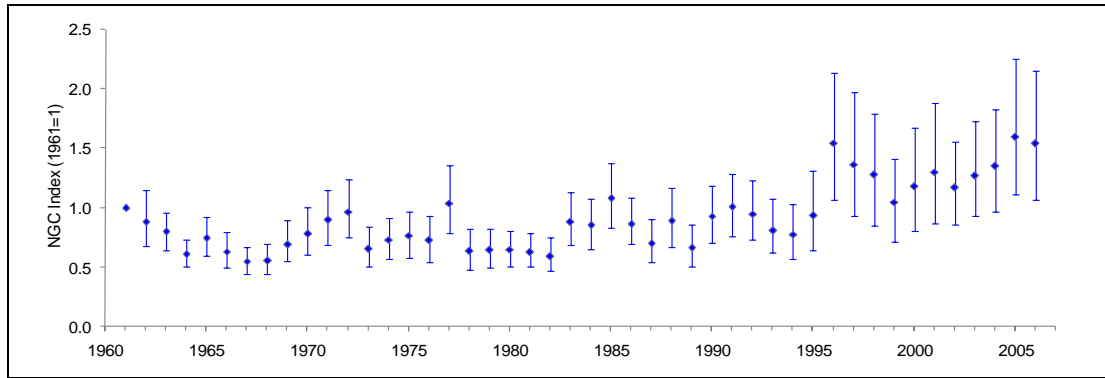


Figure 8.2 Change in relative number of grey squirrels culled per unit area in the UK during 1961-2006. Bars represent 95% confidence intervals. Data from GWCT's National Gamebag Census.

The comparison of grey squirrel culls between estates inside and outside red squirrel reserves was limited owing to the low number of estates inside reserves that returned NGC data. Returns were received from only five estates in 2005/06 and six reserves in 2006/07. Of these, none of the five estates culled grey squirrels in 2005/06 and only three of the six culled greys in 2006/07. Based on this latter data, the mean grey squirrel cull was nominally lower on estates inside red squirrel reserves (0.64 ± 0.59 greys per km^2) compared to estates outside reserves (1.56 ± 0.40 greys per km^2). The mean density of game keepers was nominally higher inside reserves (0.110 ± 0.03 keepers/ km^2) than outside reserves (0.064 ± 0.006 keepers/ km^2).

Table 8.7 Grey squirrel bags and keeper densities from estates inside and outside reserves in Northumberland, North Yorkshire, Cumbria, Durham, Tyne And Wear, The Borders, Dumfries & Galloway, Lancashire and Merseyside. Data from GWCT's National Gamebag Census.

	2005			2006		
	In	Out	All	In	Out	All
ALL SHOOTS	5	99	104	6	105	111
Total shoot area (km^2)	40.5	2190.3	2230.8	66.8	2834.1	2900.9
Total bag	0	3373	3373	38	2895	2933
Weighted mean bag density (bag/ km^2)	0.00	1.54	1.51	0.57	1.02	1.01
SE of weighted mean bag density	0.00	1.54	0.33	0.57	1.02	0.25
Total keepers	4	159	163	7	183.5	190.5
Weighted mean keeper density (keepers/ km^2)	0.099	0.073	0.073	0.105	0.065	0.066
SE of weighted mean keeper density	0.040	0.005	0.005	0.030	0.005	0.005
SHOOTS WITH NON-ZERO BAGS	0	61	61	3	65	68
Total shoot area (km^2)	-	1607.7	1607.7	59.7	1859.8	1918.9
Total bag	-	3373	3373	38	2895	2933
Weighted mean bag density (bag/ km^2)	-	2.1	2.1	0.64	1.56	1.53
SE of weighted mean bag density	-	0.49	0.49	0.59	0.40	0.39
Total keepers	-	110.5	110.5	6.5	120.5	127
Weighted mean keeper density (keepers/ km^2)	-	0.069	0.069	0.110	0.064	0.066
SE of weighted mean keeper density	-	0.006	0.006	0.030	0.006	0.006

Discussion

Trends derived from culls are unusual compared with ones from standard population monitoring programmes because the data analysed represent numbers of animals killed rather than counts of live animals. As a result, there are potential biases

associated with bag data that do not occur with count data, and that can obscure an underlying trend or create the appearance of a change in abundance where none has occurred. An obvious difficulty is that culling can itself be the cause of changes in the abundance of a species - the method of data collection has a direct impact on the quantity it intends to measure!

Another potential source of bias is the fact that the number of animals killed is a function both of the abundance of animals on the ground and of the amount of effort invested in culling them. For grey squirrels, the number of gamekeepers per site, number of traps set, type of trap and duration of trapping will all influence effort and contribute to variation in numbers of animals killed. In practice, it appears that much of this variation merely adds noise to an underlying trend that reflects population density (Whitlock *et al.* 2003).

Comparisons with trends obtained from other surveys such as the Breeding Bird Survey (BBS) are one way in which it is possible to assess possible bias caused by culling impact or changes in effort. In the case of the grey squirrel, BBS data are available for the period 1995-2005 (Davis *et al.* 2007). At the UK level, they show a 42% increase, which is identical to the UK 1995-2006 trend from the NGC. At the country level, BBS data show a 40% increase for England, which again is identical to the English NGC 1995-2006 increase. For Wales, where sample sizes are less than a tenth of those available for England, the increases are 56% (BBS) and 78% (NGC), and do not differ significantly. It appears therefore that grey squirrel trends derived from cull data are reliable indicators of population change.

The NGC results reflect not only the temporal increases in the UK, but also give an indication of the timing of the spread of the grey squirrel across Great Britain over time. Thus, for instance, the NGC holds very few Scottish cull records before 1977, but numbers then tripled over the next 30 years. It is clear that this represents the situation before and during colonisation. Likewise in north-east England, the lack of cull data before 1995 emphasizes the relative absence of the grey squirrel in the area until very recently. In both Scotland and the north-east, once colonisation has started, the NGC trends indicate a rapid increase in density, of the order of 5-10% per annum at least initially.

Interpretation of the grey squirrel bags from estates within and outside reserves and buffer zones is unclear. A nominally lower bag would intuitively be expected from estates inside a reserve reflecting lower density of greys in this habitat. However, it is not known whether the three estates inside reserves are signed up to Woodland Grant Schemes and, therefore, whether the bags represent background pest control or red squirrel conservation effort.

8.4 EVALUATION AND RECOMMENDATIONS

Despite local successes, such as the control of grey squirrels in and around the Whinfell reserve, this review has found no convincing evidence that the grey squirrel control operations that have been carried out for red squirrel conservation in the North of England have had any effect on the regional distribution of grey squirrels and, by implication, population numbers. Trapping schemes whether carried out by individuals or organisations tended to highlight numbers of greys killed rather than how many were left. It was unfortunate that the people running trap loan schemes

claimed they received so little feedback from volunteers that it was difficult to know what had been achieved. There has been a distinct lack of systematic monitoring in most places, which has compounded the problems about the effectiveness of control. There was no evidence that the efforts of landowners and volunteers were being actively directed towards either a local Area Exclusion Strategy or a Regional Defence Strategy as suggested by Gurnell & Pepper (1993). By default, the control tactics became fragmented, instead of the targeted and sustained control effort that was needed. The fundamental reason for this was undoubtedly inadequate funding for 'grey' control, aggravated by disagreement among the different organisations over the conservation strategy and an apparent reluctance of some landowners to control grey squirrels. Consequently, assessing the detailed economics of red squirrel conservation has been impossible as most of the information on control has been qualitative, with a notable absence of data on the effort expended (e.g. number of trap nights).

During the interviews and from the questionnaire returns it was apparent that the different organisations were pursuing their own agenda regarding the removal of grey squirrels. For example, RSPP was attempting a regional (i.e. county-wide) eradication, SOS promoted control in and around the reserves and some volunteer groups were seeking local area (e.g. parish) eradication. For the different efforts to be additive, there needed to be a degree of organisation and coordination similar to that set up to eradicate the coypu *Myocastor coypus* in the 1980s, but this appeared to be lacking. Indeed, the successful coypu eradication campaign helped establish principles applicable to the management of any vertebrate and thus should apply to control of the grey squirrel even if total eradication is unachievable. These included setting a target population density over a defined area, which could be independently verified (Gosling & Baker, 1989). The target need not always be eradication, but could be a density low enough to prevent problems occurring. Control should be organised centrally, although local organisations, properly coordinated, might be just as effective. Control operatives need to be rewarded for achieving their objectives, but where incentive schemes are used, results should be independently monitored. Most importantly, estimates of trapping effort, population trends and the results of field checks need to be presented to the funding organisations so that they can evaluate their financial investment at regular intervals during the campaign.

The benefits of a culling strategy that is designed and coordinated centrally are further exemplified by the mink *Neovison vison* eradication programme on the Uist Islands, Scotland (Roy 2006). Initial control efforts on the Islands involved uncoordinated local action by various stakeholders, each with varying objectives, resources and time-scales. Control was ineffective. Later, these stakeholders became a loose collective with the formation of the Uist Mink Group; although nominally coordinated the control remained ineffective. The initiation of the formal eradication project, funded by Scottish National Heritage and the European Union and designed and managed by the Central Science Laboratory, resulted in coordinated and effective landscape-scale adaptive management resulting in successful eradication of mink from the target area of the Uists.

Red squirrel conservation efforts suffered from a lack of funding to employ enough full-time professional control operatives, resulting in a large number of volunteers being recruited to help control grey squirrels, mainly through the running of trap loan schemes. Save for hearsay that questioned the competence of some unnamed

individuals, there was no evidence that squirrels were being killed by inappropriate (i.e. inhumane) means. Equally, there was no evidence that the highest standards of animal welfare were being maintained during despatch procedures. In particular, relying on landowners/occupiers to report the capture of squirrels to a trapper must be regarded as poor practice, because of the risk that such captures will be reported late or not at all: one interviewee cited a case where this had occurred.

A review of the methods that interviewees said they or their agents used to control grey squirrels is given in Appendix 8, which discusses some unresolved issues about the practice and humaneness of the despatch methods currently being used by trappers and shooters. For example, the 'Sack' method is condemned by some and promoted by others and shooters seem uncertain about how many shots it is 'legal' to fire at a squirrel. Some control methods, such as the use of kill-traps and firing 'blind' into dreys, seem likely to risk harming red squirrels or are inherently dangerous unless effective risk reduction measures are taken. An audit of despatch procedures, similar to one carried out during the Randomised Badger Culling Trials would help resolve these issues and reassure the public that while the culling of grey squirrels remains necessary, it is being carried out as competently and humanely as possible. Aside from an audit, there should be sufficient supervision of all professional and volunteer operatives to ensure that standards are being maintained.

Another important factor during a culling campaign is the impact the control methods are having on non-target species. Although the questionnaire did not specifically ask for information on the numbers of other animals caught and released or found dead, it was admitted during the interviews that 'occasionally' non-targets were caught. This is inevitable during wildlife management operations as few, if any methods are completely species-specific. For the reassurance of funding organisations and the public, the numbers and species of non-target animals caught or shot should be recorded. While there is no specific threshold for catching non-target animals, above which a control method becomes 'unacceptable', it may be necessary to modify a procedure if 'too many' are caught. As an example, coypu were live-trapped and then shot in the trap during the eradication campaign: from a sample of 33,067 trap-nights, 1,108 non-targets were caught (3.4%); non-target mortality (i.e. animals found dead in the trap) recorded during 5,105 trap nights was 13 (0.25%) (Gosling, Baker & Clarke 1988). These rates of capture and mortality could be used as guidelines to assess the impact of future grey squirrel control operations although they are arbitrary.

Very few organisations or individuals collected data in a format that was amenable to an analysis to show progress in reducing the distribution and abundance of grey squirrels in reserves, buffer zones or elsewhere. With appropriate data, it would have been possible, for example, to produce a graph similar to the one shown below (Fig. 8.3) suitable for incorporating into progress reports to funding organisations. For this to happen, record keeping should be standardised with a condition in future funding agreements that all participants will use a standard form and that minimum data requirements are specified. Data collected during trapping should be, at least, the location (i.e. OS Map ref, GPS coordinates) of each trap, the date it was set and what was caught including a nil return (i.e. no catch) (see Section 10). Additional information, such as the sex and body weight of each grey squirrel would also be helpful. The method used to despatch each squirrel should also be recorded, as well as its efficiency (i.e. how many blows/shots were taken). (It is important to emphasise

that this information should be used to review, and if necessary, modify procedures and not to criticise operators who may be doing their best to despatch a squirrel humanely under, sometimes, difficult circumstances.)

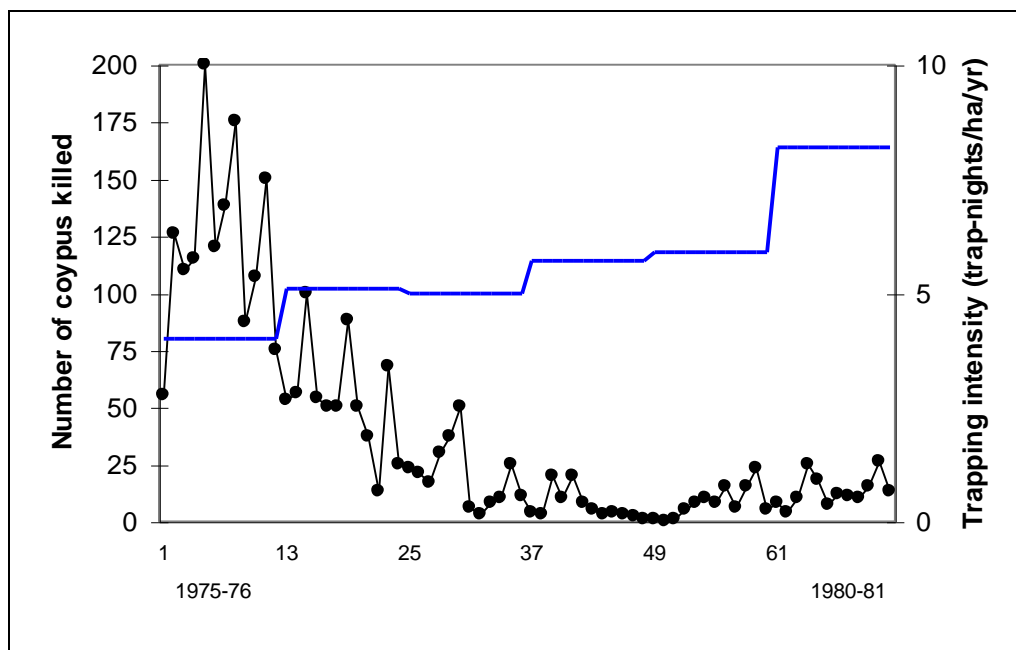


Figure 8.3 Graph from Gosling, Baker & Clarke (1988) derived from data collected during the coypu eradication campaign: the x axis shows the time scale (months), the primary y axis the number of coypu killed each month (black line) and the secondary y axis the trapping effort expressed as trap-nights/ha/yr (blue line). Similar graphs could be constructed with relevant timescales, to show, for example, the effects of trapping in reserves, buffer zones or other defined area where grey squirrel control is carried out.

Recommendations

- 8.4.1 Ideally, to maintain high standards of animal welfare, all grey squirrel control should be carried out by skilled, full-time, paid operatives. In practice, trained and competent volunteers should not be excluded, provided there is appropriate supervision.
- 8.4.2 Produce a detailed Standard Operating Procedure (SOP) for each control method and despatch procedure.
- 8.4.3 Carry out an audit under field conditions (supervised by an animal welfare organisation e.g. UFAW) of despatch procedures to establish their efficiency (humaneness). Audit report should include recommendations on changes, if necessary, to the SOPs to improve efficiency. Subsequent audits may be advisable.
- 8.4.4 Set objectives for control: define area, timescale, trap density, population density endpoint.
- 8.4.5 Aim to include as many landowners as possible.

- 8.4.6 During control, record effort (e.g. number of trap-nights, number of shooting days), numbers of squirrels and non-targets caught/shot, traps sprung without catching, location (OS map reference) of each squirrel caught/shot.
- 8.4.7 Monitor changes in grey squirrel populations systematically.
- 8.4.8 The EWGS grant rates should be reviewed.

9. HABITAT MANAGEMENT

9.1 OVERVIEW OF CURRENT ADVICE

Most guidelines have been developed for red squirrel populations in large conifer forests (see section 4.3) and include the selection and maintenance of areas that do not contain large-seeded broadleaves, the provision of a dependable seed food supply through a variety of conifer and shrub species and where appropriate, advice on harvesting, thinning and forest restructuring (Gurnell & Pepper 1988, 1993, Lurz *et al.* 1995, 1998, Pepper & Patterson 1998):

- It is unclear what constitutes a minimum viable population of red squirrels, but a size of 200 individuals has been suggested
- An area of conifer forest between 2,000-5,000 ha has been considered ideal but a minimum population could perhaps also be achieved in smaller, high quality conifer forests
- The age structure (based on 45 year rotation forest) should be around one-third of each of the following tree age classes: <15 years, 15-30 years, older than 30 years.
- Most managed conifer forests consist of a patchwork of tree species within which red squirrels will track changes in annual seed food availability
- In order to minimise the competitive advantages grey squirrels enjoy in deciduous woodlands containing oak, beech, sycamore, chestnut or hazel, forests selected as conservation areas should not contain large-seeded broadleaves
- Native broadleaf planting in conservation areas should focus on species such as birch, rowan, ash, willow, aspen and alder which have general conservation value but do not encourage grey squirrels
- In order to provide a more dependable food supply for red squirrels between years, forests dominated by Sitka spruce should contain a proportion of other conifer species such as larch, pine or Norway spruce. Attention should be paid to seed phenology and the known intervals between good and poor seed crops of individual species
- Self-thinning mixtures can offer benefits to red squirrels by providing additional food sources for some time during a rotation
- Thinning should be tailored where possible to improve seed production
- Avoid fragmentation of forest blocks to ensure red squirrel movement
- Forests should be planned to maximise beneficial seed production by encouraging:
 - south-facing aspects
 - irregular shapes to increase periphery
 - creation of uneven-aged woodland to ensure constant supply of seed producing trees
 - alternative silvicultural systems to clearfelling
 - different tree species
- Where possible, such management options for red squirrel reserves should be developed in collaboration with local foresters who are familiar with the woodland and can advise on the most sensible options with respect to tree species choice, planting or harvesting operations
- Diversification of Sitka spruce dominated plantations for red squirrels will assist other seed eating species associated with conifer forests such as siskins, crossbills and small rodent species.

Management guidelines for reserves and buffer zones are also available for landowners as part of the SOS project (see Appendices 5 and 6). It should be noted that not all recommendations may be applicable to every woodland; specific habitat management will depend on local circumstances.

9.2 COMPARISON BETWEEN ORGANISATIONS' ACTIVITIES WITH RECOMMENDED PRACTICES

None of the surveyed organisations with the exception of the Forestry Commission carry out habitat management. Landowners within reserves have been asked to sign a Memorandum of Understanding (see Appendix 4) to formalise commitment to red squirrel conservation and signing-up to management guidelines. SOS provides advice to landowners. Furthermore, habitat management is a long term option and the planting of trees, for example, to assist red squirrel food supply will generally take >25 years to mature. The three-year focus of the review (Nov 2005-present) is, therefore, too short a time frame to draw any conclusions with regard to effectiveness and success. Management and advice, however, do follow best practice guidelines.

The only longer term data set is available for Kidland Forest that has been monitored by Forestry Commission, Kielder Forest District since 2001. Habitat management for red squirrels (long-term retentions of non-Sitka spruce conifers and adjustment of felling) linked to monitoring over the last seven years at the reserve has indicated that population size has been closely linked to the size of annual seed crops. No adverse effects of harvesting operations on overall estimated population size have so far been detected (Lurz 2001-2007, Lurz *et al.* 2008).

9.3 EVALUATION AND RECOMMENDATIONS

The interview with SOS staff has indicated that in the two years of the project, no comprehensive list of woodland landowners in reserves and buffer zones has yet been compiled. This action and the importance of maps and GIS were highlighted by members of the Steering Committee in the summer and autumn of 2007 (Minutes SG 6.7 2007, SG minutes 16.10.2007). It represents a failure in the project delivery and makes any assessment with regard to the potential coverage achieved in signing up landowners for woodland grants within reserves and buffer zones impossible. The key objective of red squirrel conservation should be effective action on the ground. It should have been a priority to compile a landowner list in order to provide information on the spatial distribution and areas covered by grants for both habitat management and grey squirrel control to guide conservation actions and set targets.

Interviews also highlighted the need for a habitat management strategy. The Dales reserves in particular, illustrate the need to examine the long-term future of the reserves and to develop an integrated management plan for the different regional groups of reserves (Dales, Cumbria, Slaley, Kielder) as a system. The even-aged nature of the plantations in the North Yorkshire Dales currently at the peak of cone production and the need for restructuring and replanting in the near future means that local red squirrel populations will not be sustained in the longer term. The new reserve at Greenfield provides opportunities to manage the reserves as a system with local population declines and re-colonisation events once the new plantations mature. The aims of an integrated plan should be an interlinked reserve system with a mixture of long-term retentions (where possible due to high wind-throw risk) and conifer plantations interlinked by movement/dispersal corridors. This system should be able

to accommodate needed harvesting and restructuring and would allow the long-term retention of a viable red squirrel population within the Dales.

Recommendations

- 9.3.1 Create a comprehensive list of landowners and map awarded FC management and grey squirrel control grants.
- 9.3.2 Use list and map to direct efforts for a comprehensive grey squirrel control strategy in and around reserves and buffer zones.
- 9.3.3 Develop long-term management plans for reserves as integrated systems; areas with a need for restructuring such as the Dales are a priority.

10. DATA COLLATION

10.1 CURRENT STATUS

Given the local focus of many individuals, squirrel groups and organisations, data collected relate to local activities such as grey squirrel control activities or squirrel sightings by local residents. The types of data recorded encompassed:

- red or grey squirrel sightings reported by the public,
- sightings of squirrels as part of squirrel monitoring (e.g. red squirrel surveys at Whinfell),
- data on grey squirrels culled as part of ongoing control or in response to sightings,
- information on the disease status of red or grey squirrels.

The data format in terms of what information was recorded as well as the storage (e.g. paper or digital) varied between organisations. SOS are acting as a central contact for all squirrel data but there seemed a discrepancy between data received from SOS and data passed on to the reviewers by other organisations and groups during the current review; suggesting that not all data are passed on and shared.

With few exceptions, there was little systematic surveying and monitoring of red or grey squirrel populations in the designated reserves and buffer zones.

Also, as discussed in Section 8.4, data collation on grey squirrel control efforts was not recorded in a format that allowed the evaluation of effectiveness. Data were limited to parameters that recorded the number of grey squirrels killed, rather than the effectiveness of control on the density and distribution of the targeted population. At best, grey squirrel control data reflected the tracking of sightings. For example, figure 10.1 illustrates the variability of grey squirrel sightings (relative measure of immigration levels) into the Whinfell reserve, and the reactive approach where culls follow sightings. Data from such reactive trapping does not provide information on the grey squirrel population remaining.

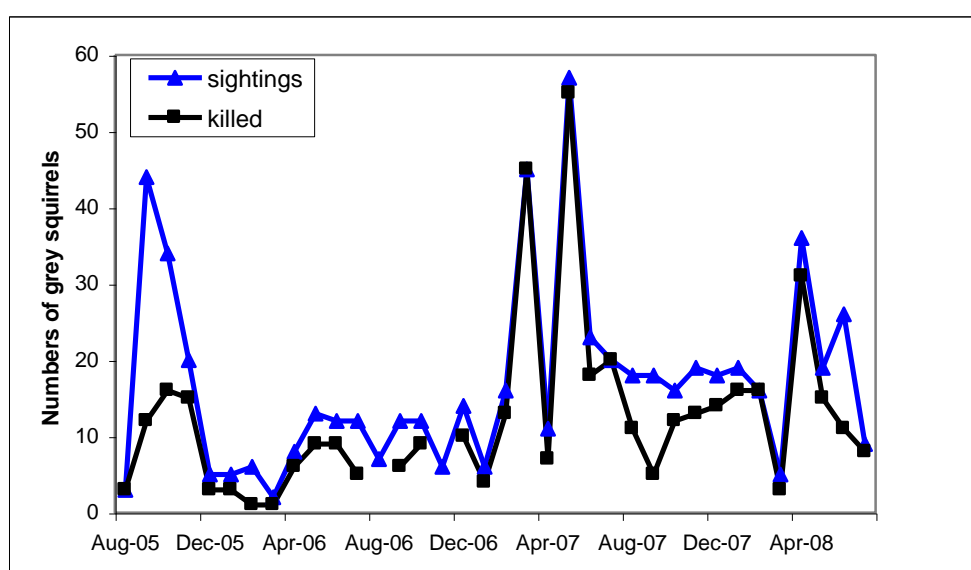


Fig. 10.1 Example of an extensive available dataset: Whinfell – sightings and kills (shoot and trap combined) of grey squirrels 2005-2008).

Another area of data collation that has been inadequately addressed is the production and maintenance of electronic maps of the reserves and wider landscape. Such maps are an integral component of monitoring baseline information and progress in relation to numerous red squirrel conservation parameters, including the basic information of landownership.

10.2 EVALUATION AND RECOMMENDATIONS

With few exceptions, data collation has been inadequate as a basis from which to evaluate and adapt on-the-ground conservation activities. One significant limitation has been the widespread absence of systematic data on the abundance of squirrels. It is recommended that:

10.2.1 A regular systematic survey of red and grey squirrel abundance and distribution is carried out, against which can be measured the effects of conservation activities.

In respect to data that has been collated, a consequence of the large number of different organisations and regional groups involved in red squirrel conservation in the North of England, including the forming of Northern Red Squirrels in 2008, has been the non-standardised collation of data, such as squirrel sightings and grey squirrel control. It is recommended that:

10.2.2 A common standard for the recording and storage of squirrel data is agreed.

10.2.3 There is agreement on a central facility to which all records can be copied.

10.2.4 A more systematic and regular approach is adopted toward data sharing.

What type of information is recorded will to some extent depend on the purpose and use for the data. For example, data collected to plot red or grey squirrel sightings may include date, location (with an agreement to data resolution, e.g. to nearest 1km or 100m), species, recorder and comments. Data collected on grey squirrel control (see also section 8.4) may also include methods of despatch, the fact that a blood sample was taken and, subsequently, information on the analysis of the blood sample and thus disease status of the individual (e.g. SQPV antibody blood test or post-mortem results).

There were two main areas where records received during the current review had insufficient information. This was with regard to a National Grid location, some data only had a local place name and without being familiar with the area, it was impossible to allocate an accurate Grid reference. Some data also recorded a 6-figure grid reference but failed to include the 100km square information given as letters on the OS map. In addition, few data were collected to give an indication of control effort in terms of the area (ha) covered, the total number of traps set and the number of trap days. It clearly has been a priority to control grey squirrels rather than record control effort. However, this combined with a lack of systematic post-control monitoring has made any assessment with regard to the effectiveness of current grey squirrel control impossible.

It is recommended that following the publication of this report, a meeting or Forum is organised with one of the agenda topics being a ‘common data standard’. It is a matter for the different organisations and groups to agree on the precise format of the standard. However, recommendations are that it should include the following information as a minimum (Figs. 10.2 & 10.3).

Data recorded during grey squirrel control should also include the number and type of non-target species killed.

Site/Wood	OS Grid/ GPS coordinates	Date	Species	Recorder	Type of Record	Comment
	e.g. AB123456				e.g. sighting, road kill, etc	

Figure 10.2 Minimum data recording requirements for squirrel sightings.

Site/ Wood	OS Grid/ GPS coordinates	Trap Area	Date (Period)	No. days	No. traps	No. trap days	No kills	No.kills/ trap day	Kills/trap day/ha

Figure 10.3 Minimum data recording requirements for grey squirrel control.

Detailed mapping of the reserves and wider landscape should be conducted using GIS software. Map layers can be produced for all relevant conservation parameters, including red and grey squirrel sightings/population densities, landownership, Woodland Grant Scheme awards, grey control effort and instigator of control (e.g. control operative, landowner, local group). Maps should be maintained and regularly updated with new information.

During the interviews of the organisations, concern was raised that whilst SOS are currently providing an infrastructure for data storage and the dissemination of maps, their funding was only short-term. Given this constraint, a longer-term solution to record collation and eventual storage should be discussed. In many areas, the collation and storage of records is being looked at on a county basis and/or through regional record centres. However, this decision should clearly be taken in relation to available resources and facilities in the North of England and involve the statutory agencies.

11. AWARENESS RAISING

11.1 INCREASED AWARENESS

Three of the four principal red squirrel conservation organisations (SOS, Forestry Commission, Northern Red Squirrels) engage proactively in raising the public's awareness of red squirrel conservation. In addition to the organisations' websites, activities include the distribution of leaflets and posters and the delivery of various types of presentations to the media and a range of targeted audiences.

The effectiveness, or value, of awareness and educational activities is very difficult to measure. However, the level of public awareness of red squirrel conservation issues will be related to the extent of coverage in the media. A search on the Meltwater News service (an electronic media monitoring system) for newspaper articles relating to red squirrels revealed an increase in articles in recent years (Figure 11.1); although the timing of this varied between regions in northern England. The increase was most apparent in the north-east, beginning earlier (2007) and of greater magnitude (around 200 articles in both 2007 and 2008). In the north-west and in Yorkshire & Humberside increases were not apparent until 2008 and involved fewer articles (around 125 and 70 respectively).

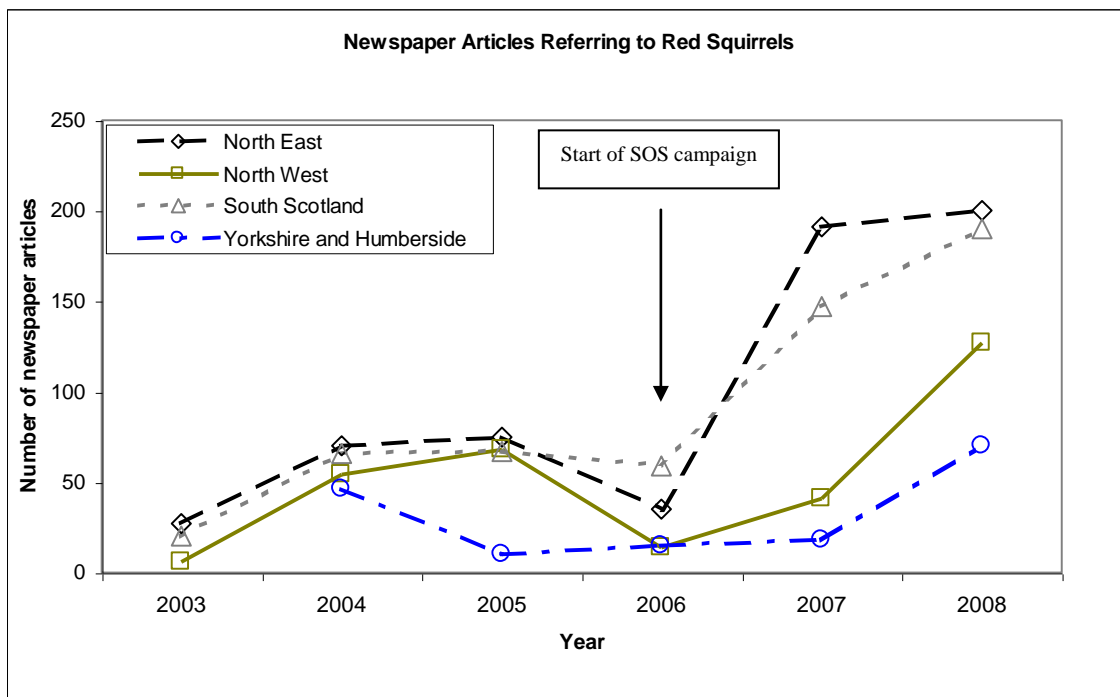


Figure 11.1 Number of regional newspaper articles relating to red squirrels between 2003 and 2008.

The increase in the volume of news coverage associated with red squirrels has been manifest subsequent to the onset of the SOS campaign (2006). Therefore, it can be argued that the awareness raising activities have been successful, in that they have contributed to increasing the public's knowledge of red squirrel conservation. However, other independent phenomena, such as the BBC's Springwatch series, will also have contributed to the increase in media coverage. The relative influence of the

conservation organisations' activities and that of others, as sources influencing the overall increase in media coverage is unknown.

For some organisations it is possible to evaluate whether delivery targets have been met, e.g. SOS has quarterly project performance targets. The SOS summary of 'Performances against Targets' (June-September 2008) actually indicates over-delivery in a number of awareness raising related objectives (e.g. 'produce printed material' +938%, 'study guidance for Uni students [on web] +11,600%). However, although the 'message' is being delivered, it is very difficult to assess the ultimate benefits of this delivery. That is, to what extent the successful access and community engagement delivery has translated into practical conservation success on the ground, i.e. stable or increasing red squirrel abundance and distribution.

11.2 EVALUATION AND RECOMMENDATIONS

Central to any red squirrel conservation strategy is the control of grey squirrels. However, for non-native species in general, and particularly for charismatic species, proposals for large-scale control or eradication are rarely universally popular as they often involve activities that are distasteful to some people (Temple 1990). It has been proposed, that to reduce the likelihood of adverse reaction and confrontations that may interfere or halt control or eradication programmes, it is necessary to educate the public about the threats posed by non-native species and build support before initiation of a programme (Temple 1990). Awareness raising and education of the public, therefore, is an essential component in the management of invasive non-native species. Such a component should be an important element within any future red squirrel conservation strategy in northern England.

Considering the SOS project's outputs with regard to performance targets against access and community engagement this component of the overall conservation strategy has clearly been successful. An increased awareness in the general public is supported by increases in the number of regional newspaper articles related to the issue of red squirrel conservation since the initiation of the SOS campaign in 2006.

Although awareness raising and education are essential elements in any red squirrel conservation strategy, the delivery needs to be targeted more effectively. Currently, it is unclear how increased levels of awareness are translated into increased funding and conservation success on the ground. In the SOS structure it can be argued that there is too much emphasis on community engagement to the detriment of work on the ground – where the majority of resources should be targeted. The SOS 'Performances against Targets' (June-September 2008) indicates over-delivery in a number of awareness raising related objectives. Performance in delivery of the majority of conservation outputs, however, is difficult to evaluate from the same source, as no annual targets were actually set. It is clear, however, that there has been under-delivery in on-the-ground measures, such as grey control coordination and mapping land-ownership in the red squirrel reserve buffer zones. In particular, the performance requirement to deliver set quotas of presentations to a wide range of specific niche audiences (often with tenuous stakeholder interest) has a very low probability of returning any tangible benefits to the implementation of practical red squirrel conservation measures. The original detriment of over-emphasis of community engagement has been exacerbated by the workload generated diverting the conservation officers from their principal tasks.

Recommendations

- 11.2.1 Realign the relative emphasis, and spending, between engagement and awareness raising activities and on-the-ground management measures to reflect a more strategic balance.

- 11.2.2 More strategic targeting of audiences for engagement and awareness raising activities. For example, increased targeting of landowners and gamekeepers is likely to produce more tangible practical benefits compared to some other audiences.

12. FUTURE STRATEGIES

The three key components of any future red squirrel conservation strategy are grey squirrel control, conservation and community engagement.

The most critical component is the control of grey squirrels. As for all pests, there are three main options for managing grey squirrels: do nothing, sustained control, and eradication. Sustained control is the most strategically difficult because to be effective it requires some understanding of the relationship between grey squirrel density and the resource being impacted (i.e. red squirrel abundance and distribution). That is, the programme must have some defined measurable objective and the level that grey squirrel abundance must be reduced to (to get the desired response of the resource) must be known. If such information is not available there is a risk that grey squirrel management focuses on killing squirrels (rather than on the numbers remaining) and not on the benefits or outcomes. However, if the required information is not known then management can be structured in such a way that this information is obtained and further refined over time as management progresses. Such an adaptive management process will be essential if eradication is not achievable. Surveys of grey squirrel density in target areas, before and after periods of culling, and the accurate recording of trapping effort are vital information in this regard. Monitoring changes in grey and red squirrel populations at a larger-scale is also necessary.

Any future strategy for the control of grey squirrels in northern England can be informed by experiences gained from the grey squirrel eradication campaign on Anglesey (710 km² in area, 3% of which is mature woodland), which has been running since 1998. Specific points are:

- Access to land and a systematic control effort are critical.
- Grey squirrels can, and do, turn up virtually anywhere including locations such as gardens or patchy scrub very close (100-150m) to sites that have been recently trapped. Control, therefore, has to be periodically repeated at sites irrespective of how long ago the last grey was caught there.
- Grey squirrel densities decline, whilst geographical spread remains relatively large; although grey squirrel free areas within that spread increase.
- Vigilance along potential ingress routes is important (e.g. mainland estates as a source of greys immigrating across the bridges into Anglesey).
- The return of red squirrels acts as a stimulus to the general public, resulting in an increase in awareness, in the number of sightings and support for grey removal.
- In some cases the impression given may be that grey squirrels are being controlled across a woodland or an estate and that grey squirrels are at low levels. However, it is possible that control is restricted to, for example, the proximity of feed rides and that many parts of the woodland resource are not trapped.

Further lessons from successful regional eradication campaigns in GB (coypu, muskrat *Ondatra zibethicus*, mink) are the necessity for the planning and implementation of the removal, or control measures, to be under the coordination of one organisation. This will ensure that systematic standardised trapping, removal and reporting protocols are deployed across all regions being targeted.

A future strategy will require:

- The support of all the key organisations in red squirrel conservation – Defra, Natural England, the Forestry Commission, the National Parks, the Wildlife Trusts, the current reserve owners and managers, and the European Squirrel Initiative/Red Squirrel Survival Trust.
- A core project team to deliver the strategy comprising a project manager, conservation officers, full-time control officers and a community engagement officer.
- Strategic partnerships will need to be maintained and further developed with other conservation organisations, in particular the local red squirrel groups; and also with landowners.
- The project team and allied groups should be coordinated and managed by a committee representing all red squirrel conservation stakeholders. This committee could be chaired by an independent person appointed by Natural England and be advised by an expert squirrel consultant.
- The project committee needs to include in its considerations:
 - The specific strategy to be adopted (see below).
 - Fund raising - for exactly what, by whom, from whom and how much. Importantly, ensure that any conditions attached to external funding do not impede the project aims (e.g. lottery funding and grey control in existing grant).
 - The control of grey squirrels. This is the key to red squirrel conservation and, in the absence of a national eradication programme, will be an ongoing, year-on-year process. In particular, the committee should consider the deployment of resources and target it appropriately. They will have to balance the idea of protecting reserves or landscapes/regions on a priority basis where they can have real effect, against the risk of spreading the resources too thinly, and achieving little in the way of red squirrel conservation. This may pose a great dilemma and lead to argument and disillusionment among representatives of local groups who see their local red squirrels as the priority. As an example, *in extremis* and with little money available, it maybe that only red squirrels within Kielder Forest District should be defended, since Kielder holds ~9,000 - the largest remaining population in the north of England (Lurz *et al.* 2003). If more money becomes available, then other reserves may be defended, or in future years, greys removed and red squirrels reintroduced as on Anglesey. Although hopefully this will not be the case, it illustrates one of the most difficult facets of red squirrel conservation work in the north of England.
 - Landowner incentivisation. Much grey squirrel control needs to be carried out on private land; however, the current funding scheme (EWGS) is too inadequate and too restricted. The scheme does not cover small woodlands (<2ha), which can comprise a significant overall proportion of woodland cover within buffer zones; such small woodlands have been shown to be important habitat for grey squirrels (e.g. Anglesey). Improved incentivisation is required to strengthen existing landowner commitment and to widen involvement to encompass land currently not under grey control.
 - The inclusion within EWGS grants of population and grey squirrel cull monitoring and recording.
 - Support for vaccine development work. With an effective vaccine, a reduction in grey squirrel control intensity (practical and economic) would be possible.

With a vaccine, reduction of grey squirrels to low densities, as opposed to complete local removal, would be adequate to prevent reds being out-competed by greys in large coniferous woods.

- The implementation of recording and data management systems.
- Advice on habitat management (see elsewhere).
- Publicity and awareness (see elsewhere).
- An independent and systematic survey of red and grey squirrel abundance at a spatial-scale that encompasses, at least, the spatial-scale of the conservation strategy, carried out at fixed intervals (e.g. every two or three years). Ideally, the survey should cover the north of England, which would inform on the overall effectiveness of the conservation strategy.

Four potential future strategies are presented ranging from do nothing to regional eradication of grey squirrels from northern England. The costs for each of these strategies represent estimates and are indicative only. They do not include all items (e.g. offices, computers) but are designed to illustrate the general magnitude of staff and set-up costs (vehicles, traps, firearms) and annual running costs (salary, fuel) associated with the different strategies. Estimates are based on information on current costs provided by some of the conservation organisations. The first year costs are greater as they include the purchase of capital equipment (e.g. vehicles, traps, firearms, etc.)

12.1 DO NOTHING

Rationale

Maintain the status quo of the present conservation strategy with no replacement scheme following the lifetime of the currently funded SOS campaign in 2010.

The likely long-term outcome of this is the gradual loss of red squirrels from all reserves, except for retention in the main reserves, such as Kielder and Whinfell.

The wider issue here is at what point should a species be declared unsalvageable; a necessary debate that extends to many threatened UK species. In the case of the red squirrel, in the case of the failure to develop an effective SQPV vaccine this issue will need to be considered with regard to mainland populations.

Estimated cost

No new costs - funding is covered by the existing budget for the SOS campaign.

12.2 RESERVE-BASED

Rationale

This strategy retains the reserve-based approach but aims to improve the existing situation by using full-time operatives to control grey squirrels in each of the reserves/reserve-systems and buffer zones. Under the current scheme trapping effort is inadequate. With only two full-time operatives, control has relied heavily on volunteers and trap loan schemes, resulting in fragmented and uncoordinated effort. A greater number of full-time operatives will permit a strategic and coordinated programme of control, including more efficient liaison with local groups (NRS).

This option should include a reassessment of the suitability of each of the sites as a designated reserve. If necessary other potential sites should be examined and selected as alternatives.

The strategy will involve eight control operatives, covering eight reserve or reserve-systems (Table 12.1):

Table 12.1 Composition of the proposed eight reserve/reserve-systems.

No.	Reserve or reserve systems components			
1	Kyloe			
2	Uswayford/Kidland			
3	Kielder Forest			
4	Harwood/Raylees			
5	Dipton/Dukeshouse	Healey/Kellas	Slayley/Dukesfield	
6	Greystoke	Whinfell	Whinlatter	Thirlmere
7	Garsdale/Mallerstang	Widdale	Greenfield	
8	Sefton			

Estimated cost

Year 1 £495k

Year 2+ (annual cost) £320k

12.3 LANDSCAPE -BASED

Rationale

A strategy based on reserves but which also incorporates the management of important habitat within the wider landscape. This strategy advocates the coordinated management of reserves within the same geographic region (reserve-systems). The strategy also recognises the need to protect the significant populations of red squirrels located outside the reserves and buffer zones. This will involve a strategic partnership between the reserves and local groups, with the local groups controlling greys outside of the reserves and buffer zones. Further control will remove grey squirrels from ecologically significant habitat, including dispersal corridors and immigration routes (e.g. river valleys) and reservoir woodlands. The strategy aims to eradicate grey squirrels locally and to limit immigration into reserves and buffer zones. There would be a cross-border link-up with control operations in Scotland.

The strategy would involve six regional reserve-systems: Kyloe, Kielder, Slayley, Lake District, Yorkshire Dales and Sefton. Each system would be allocated a grey squirrel control officer. Additional control operatives outside the reserves would link up with voluntary grey control effort by local groups (two operatives), and also support grey control in Scotland and the operatives in the Kielder system (two further operatives - one each in the Solway area and north-east Northumberland) (Table 12.2).

The actual boundaries of the reserve-systems and managed wider landscape would need to be determined based on relevant ecological criteria and agreed by the wider conservation partnership.

Table 12.2 Composition of the proposed six reserve-systems and regional distribution of grey squirrel control officers.

Region	Reserves				Operatives
Kyloe	Single reserve				1
Kielder	Kielder Forest	Kidland	Uswayford	HarwoodRaylees	3
Slayley	Slayley/Dukesfield	Dipton/ Dukeshouse	Healey/Kellas		1
Lake District	Whinlatter	Greystoke	Thirlmere	Whinfell	1
Yorks. Dales	Garsdale/Mallerstang	Widdale	Greenfield		1
Sefton	Single reserve				1
Solway	Support grey control in Scotland and west Kielder				1
North-east	Support grey control in Scotland and east Kielder				1
Roving	Support grey control efforts by local groups				2

Estimated costs

Year 1 £660k

Year 2+ (annual cost) £410k

12.4 REGIONAL ERADICATION

Rationale

The aim of this strategy is to eradicate grey squirrels from northern England. The approach would, involve widening the landscape-based control (12.3 above) to include systematic culling in all grey squirrel suitable habitat in northern England. Eradication would need to be carried out by a team of full-time control operatives employed and managed by one organisation. This centrally organised control structure has been used in previous successful regional eradications of a number of species in Britain.

It is extremely difficult to estimate the costs of eradicating grey squirrels from northern England. Examining previous regional eradication programmes in Britain (coypu, muskrat, mink), and the current eradication campaign of grey squirrels on Anglesey, however, allows an insight into the probable order of magnitude of the cost.

In the 1930s, eradication of a 'large' population of muskrats from Shropshire, Surrey, East Sussex and Stirling, over seven years, cost an estimated £1.5m (1990 prices) (Baker 1990). In Norfolk, a population of coypus that peaked at between 50,000 and 100,000 in the mid-1950s was subjected to a concerted eradication effort commencing in 1981 and completed in 1987, at an estimated cost of £2.5m (1987 prices) (Gosling & Baker 1987, 1989). More recently, the first phase of eradication of mink from the Uists in the Western Isles, Scotland, took four years at a cost of £1.6 million. Currently, a five-year (2005-2010) eradication scheme to remove ruddy duck *Oxyura jamaicensis* from the UK is underway, at a cost of £3.3 million (excluding preliminary research and trials). These costs represent a mean of £215k to £660k per year; with the most recent costs at the higher end of this range.

Regional eradication of grey squirrels will exceed these annual costs as the population is dispersed through a wider area and more habitats and subject to immigration from outside the region. The grey squirrel eradication campaign on Anglesey began in 1998 and has been continuous for the following seven years. Costs, based on the budget for 2007-2010, are c.£90k per annum. Anglesey is 720 km² in area and has 2,500ha of woodland. In addition, there is also an estimated 500ha of open hedgerow/scrub and gardens with small copses or field trees that might also be considered as suitable grey

squirrel habitat. In comparison, in Cumbria and Northumberland there are approximately 146,000ha of woodland alone (Landcover 2000) - extrapolating from the Anglesey costs/unit area this is equivalent to £5.25m per year; in practice this figure is likely to be lower due to economies of scale.

As for any eradication scheme, the higher but finite costs (if successful) have to be weighed against the lower, but longer-term costs of population control and containment.

Taking the two sources of costs together:

Estimated costs

Year 1 >£1.5m

Year 2+ (annual cost) >£1.0m

An overview of the four potential strategies is presented in Table 12.3.

Table 12.3 Overview of potential future strategies

Strategy	Elements	Estimated cost		Comments and potential implications
		Year 1	Year 2+	
Do-nothing	Reserve-based Retains status quo	Existing funds	Existing funds	Current level of grey control is insufficient to prevent loss of greys from some reserves – implies potential gradual loss of red squirrels long term in absence of vaccine.
Reserve-based	Reserve-based Reserve systems-based Full-time control operatives	£495k	£320k	This would address current problem of inadequate grey control and allow control to be based on trained staff in order to guarantee health and welfare standards; strategy buys time for development of a vaccine which would make reserves viable in the long-term with some levels of continued grey squirrel control; strategy needs to be reviewed in three years in light of vaccine developments.
Landscape-based	Reserve-based Landscape control Full-time control operatives	£660k	£410k	This would address current problem of inadequate grey control and allow control to be based on trained staff in order to guarantee health and welfare standards; strategy buys time for development of a vaccine which would make reserves viable in the long-term; strategy would address immigration pressure from outside reserves; and would recognise and engage with voluntary efforts to protect important red squirrel populations outside reserves; needs to be reviewed in three years in light of vaccine developments.
Regional eradication	Full-time eradication team	>£1.5m	>1.0m	May not be feasible with current techniques (Gurnell & Hare 2005); would still suffer from high levels of immigration from outside controlled area; may be able to take advantage of geographical barriers.

Note: options 1-3 would involve year-on-year control of grey squirrels, the adoption of which should, therefore, also include support for vaccine development work.

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APPENDICES

- 1. Copy of questionnaire**
- 2. List of organisations and number of interviewees**
- 3. Red Alert North of England Terms of Reference**
- 4. MOU for squirrel reserves**
- 5. Management guidelines for squirrel reserves in northern England**
- 6. Management guidelines for reserve buffer zone**
- 7. Analysis of GWCT's grey squirrel Game Bag Census data**
- 8. Review of humaneness of methods to despatch grey squirrels**

APPENDIX 1: COPY OF QUESTIONNAIRE

A Details of Interviewee

- 1 Name:
- 2 Organisation:
- 3 Position:
- 4 Contact details:
- 5 What geographic area do you cover?
- 6 If known, give area and type of land covered?
- 7 What sort of squirrel management are you involved with?
 - a Grey squirrel control
 - b Managing habitat for red squirrels
 - c Education, public awareness
 - d Research
- 8 How is management policy decided?
 - a Committee
 - b Individual following consultation
 - c OtherIf other, provide further details

If you ticked 'Yes' to 7a, please fill in Section B

B Grey squirrel control

- 1 What methods do you use to control grey squirrels?
 - a Live trapping followed by euthanasia
 - I. Do you use the 'Sack' method?
 - II. Do you shoot the squirrel in the trap?
 - III. Do you use a lethal injection?
 - IV. If other, please state
 - b Shooting
 - I. Drey shooting
 - II. Other (e.g. shooting squirrels on tree trunk or on ground)
 - c Kill traps (e.g. Fenn traps)
 - d OtherIf other, please provide further details
- 2 Do you carry out control:
 - a In response to public sightings
 - b As a result of carrying out systematic survey work
 - c Routine on-going control as part of a programme
 - d OtherIf other, please provide further details
- 3 Do you control grey squirrels for
 - a Red squirrel conservation
 - b Tree damage prevention
 - c Both
- 4 If for red squirrel conservation, is the aim of the control to:
 - a Remove grey squirrels completely from a target area
 - b Reduce the number of greys
 - c Prevent the transmission of Squirrelpox virus from greys to reds
 - d OtherIf other, please provide further details
- 5 Who carries out the control? Indicate number of operatives in box?
 - a Full-time control operative
 - b Part-time control operative
 - c Reserve warden
 - d Forester
 - e Volunteer
 - f OtherIf other, please provide further details
- 6 Do you target control:
 - a Inside a designated red squirrel reserve
 - b In the buffer zone next to a designated red squirrel reserve
 - c In relation to damage to vulnerable tree crops
 - d Generally in any habitat where grey squirrels have been seen
 - e OtherIf other, provide further details
- 7 How often do you carry out control in the same area
 - a Continuously
 - b Monthly
 - c Quarterly

- d Annually
e Other
- If other, provide further details
- 8 If you use live traps do you use:
a Single-capture traps
b Multi-capture traps
- 9 Do you carry out surveys in and around your control areas:
a Before control
b During control
c After control
d No
- 10 If you carry out surveys, which method(s) do you adopt:
a Systematic visual counts
b Casual sightings
c Hair tubes
d Cone transects
- 11 Who carries out the surveys:
a Full-time control operative
b Part-time control operative
c Reserve warden
d Forester
e Volunteer
f Other
- If other, provide further details
- 12 Have you set up agreements to control grey squirrels
a With landowners within designated reserve areas
b With landowners in buffer zones next to reserve areas
c With landowners in non-reserve areas
- 13 Can you provide details of agreements?
- 14 Can you provide maps (hard copy or electronic) of areas where grey squirrels have been controlled?
- 15 Can you provide data on the number of grey squirrels killed?
a If greys caught by live trapping, in relation to effort (indicate area, no. traps and total days
b If greys shot, in relation to effort (indicate area, no. operatives and days shooting)
c If greys killed by kill traps, in relation to effort (indicate area, no. traps and total days)
- 16 What period of year is control carried out?
- 17 Do you consider the control has been successful in achieving your aims as indicated in sections B3 and B4?
- 18 How much do you spend on control each year?
- 19 Who pays for the control?
- 20 Will you continue to control grey squirrels:
a Indefinitely
b For 1 more year
c No
d Other
- If other, provide further details
- 21 Any other information

If you ticked 'Yes' to 7b; please fill in Section C

C Habitat management for red squirrel conservation

- 1 Have you carried out habitat management:
a Within a designated reserve
b In the buffer zone next to a reserve
c Other
- If other, provide further details
- 2 Have you set up agreements to manage habitats
a With landowners within designated reserve areas
b With landowners in buffer zones next to reserve areas
c With landowners in non-reserve areas
- 3 Can you provide details of agreements?
- 4 Does the habitat management entail:
a Felling large-seeded broadleaves
b Planting Sitka spruce
c Planting conifers to diversify food resources for red squirrels
d Avoiding planting pine
e Planting small-seeded broadleaves instead of large-seeded broadleaves
f Avoiding tree thinning/felling when red squirrels are breeding
g Providing corridors for red squirrels in red squirrel refuge areas
h Other
- If other, please provide details
- 5 Can you full provide details of habitat management?
- 6 Can you provide maps (hard copy or electronic) of areas where management has been carried out?

- 7 Can you provide an indication of the size of area where management is carried out?
- 8 Do you carry out squirrel surveys in and around your managed habitats:
- 9 If you carry out surveys, which method(s) do you adopt:
- a Systematic visual counts
 - b Casual sightings
 - c Hair tubes
 - d Cone transects
- 10 Who carries out the surveys:
- a Full-time control operative
 - b Part-time control operative
 - c Reserve warden
 - d Forester
 - e Volunteer
 - f Other
- 11 How much do you spend on habitat management each year?
- 12 Who pays for the habitat management?
- 13 Any other information

If you ticked 'Yes' to 7c; please fill in Section D

- D Education**
- 1 Do you collate sightings data with volunteers?
- 2 What method do you use?
- a Casual sightings
 - b Cone transects
 - c Hair tubes
 - d Systematic visual counts
 - e Please give an indication of what areas you cover
- 3 How do you collate the data?
- 4 How do you store the data?
- 5 Do you carry out fund raising activities?
- 6 Do you provide educational material?
- 7 Do you write articles or appear on the radio or tv?
- 8 Do you present talks to the public?
- 9 Do you employ a dedicated squirrel officer?
- a Full-time
 - b Part-time
- 10 How much do you spend on PR a year?
- 11 Any other information

If you ticked 'Yes' to 7d; please fill in Section E

- E Research**
- 1 Provide details of research activities
- 2 How much do you spend on research a year?
- 3 Who funds the research?
- 4 Any other information?

APPENDIX 2: LIST OF ORGANISATIONS AND NUMBER OF INTERVIEWEES

No.	Organisation	No. Interviewees
1	Centre Parcs	2
2	Cumbria Wildlife Trust	1
3	Natural England - Cumbria Team	1
4	Ford & Etal Estates	1
5	Forestry Commission (FC)	5
6	Local Groups (Northern Red Squirrels)	25
7	Red Squirrel Protection Partnership (RSPP)	2
8	Save Our Squirrels (SOS) (including those employed by Lancashire Wildlife Trust)	9
9	United Utilities	1
10	Yorkshire Dales National Park Authority	1
11	Northumberland National Park	1
12	People's Trust for Endangered Species (PTES)	1
13	European Squirrel Initiative (ESI)	1
14	Wildlife Ark Trust (WAT)	1
15	Scottish National Heritage (SNH)	1
16	Scottish Wildlife Trust (SWT)	1
17	Forestry Commission Scotland (FCS)	1
18	Red Squirrels in South Scotland (RSSS)	1
19	Scottish Estates	1
19	TOTAL	57

A further three people did not submit responses to the questionnaire.

APPENDIX 3: RED ALERT NORTH ENGLAND (RANENG) TERMS OF REFERENCE

Purpose

The purpose of Red Alert North England is to encourage and co-ordinate red squirrel conservation in northern England consistent with the northern England red squirrel conservation strategy¹.

Origin

Red Alert North England has evolved from two starting points.

- Firstly, from the North England Red Squirrel Conservation Steering Group that was established by the Forestry Commission to develop a broadly supported northern England red squirrel conservation strategy and to facilitate funding applications and other measures to help to deliver that strategy.
- Secondly, from the agreed merger of Red Alert North West (RANW) and Red Alert North East (RANE), initiatives based with Cumbria Wildlife Trust² and Northumberland Wildlife Trust respectively, to produce a single strategic umbrella initiative to drive forward red squirrel conservation in northern England.

Status

RANEng is the umbrella initiative driving forward red squirrel conservation in northern England. It is not a legally constituted organisation but is a partnership composed of key stakeholder organisations with relevant expertise and who are committed to working together for red squirrel conservation.

Funds

RANEng is not a fund holding body. Delivery of red squirrel conservation activity will be undertaken by the individual organisations that form the RANEng partnership. For example, the Save our Squirrels Project managed by NWT will raise funds for red squirrel conservation that will be held in a restricted account by Northumberland Wildlife Trust.

Steering Group

RANEng is managed by a Steering Group, the membership of which is:

- Northumberland Wildlife Trust
- Cumbria Wildlife Trust
- Wildlife Trust for Lancashire, Manchester and North Merseyside
- Forestry Commission (North East and North West and including FE)
- Natural England
- Northumberland National Park Authority
- Lake District National Park Authority
- Yorkshire Dales National Park Authority
- Private red squirrel reserve owners (representative)
- Forestry and Timber Association
- Center Parcs
- RANEng Cumbria Forum (Chair)
- RANEng Northumberland forum (Chair)
- RANEng Sefton Forum (Chair)
- University of Newcastle
- Red Squirrels in South Scotland
- Save our Squirrels (Project Manger)

¹ The northern England red squirrel conservation strategy is to focus red squirrel conservation efforts at 16 carefully selected forests (red squirrel reserves) and the land immediately surrounding them (buffer zones) in order to maximise the chances of the species persisting in mainland England for the benefit of current and future generations.

² Lancashire, Manchester and North Merseyside Wildlife Trust have worked alongside Cumbria Wildlife Trust as key partners in RANW.

There will normally be one representative of each of the above organisations on the steering group although additional representatives may be invited at the Chairman or vice Chairman's discretion. Each Wildlife Trust will normally be represented by a trustee and member of staff. The group is not a closed one and organisations or individuals not listed above may also be invited to join the Steering Group subject to the agreement of the majority of the Group but the size of the Group will not exceed 25 people to ensure that it remains effective and manageable.

The terms of reference for the Steering Group are:

- Provide guidance and direction to the Save Our Squirrels Project and any other cognate project that is delivering to the North of England Red Squirrel Conservation and Access Strategy. This to include monitoring delivery of projects in relation to agreed output and outcome targets.
- Act as the formal conduit between the North of England Red Squirrel Conservation Strategy, the SOS Project and the UK Red Squirrel Group and England Squirrel Forum.
- Share information and spread best practice on red squirrel conservation.
- Co-ordinate red squirrel conservation activities across the north of England.
- Identify resources to sustain red squirrel conservation and access into the future.
- Review and update the North of England Red Squirrel Conservation and Access Strategy as appropriate.
- Maintain dialogue and linkages with red squirrel conservation efforts in southern Scotland and seek closer integration of activities in the two areas.
- To link with and provide the umbrella body for local red squirrel conservation groups, land managers and other red squirrel conservation practitioners and the general public.

Chairman:

The Steering Group shall select a Chairman and vice Chairman from the members of the Group. Each will stand for a term of 1 year at the end of which they may stand down or offer themselves for re-selection.

Meetings:

The Steering Group shall normally meet quarterly or more frequently when this is judged to be necessary by the Group. The Chairman or Vice Chairman will arrange for an agenda and any supporting papers to be circulated in advance of the meetings.

Review:

These terms of reference shall be reviewed by the Steering Group in 12 months time and thereafter as agreed is necessary by the Steering Group.

APPENDIX 4: MEMORANDUM OF UNDERSTANDING

**North England Red Squirrel Conservation Project
(Red Alert North England)**

We [organisation/company name] as the organisation responsible for the management of [reserve name] as identified on the attached map, agree to manage this site to conserve red squirrels by following the guidelines at Annex A, subject to receiving an agreed level of financial assistance from Red Alert North England and/or the Forestry Commission to enable us to do so.

We [organisation/company name] strongly support the aim of red squirrel conservation. We are content for [reserve name] to be identified as a red squirrel reserve and for Red Alert North England to undertake appropriate publicity relating to red squirrel conservation, in collaboration with us and relating to this reserve.

We [organisation/company name] agree to adhere to this MOU for an initial period of five years but in the event of a dramatic change of circumstances we reserve the right to discuss our position with red Alert North England and the Forestry Commission.

Signed.....(Red Squirrel Reserve Manager)
Date.....

Signed.....(Chairman of Red Alert North England)
Date.....

APPENDIX 5: MANAGEMENT GUIDELINES - RED SQUIRREL RESERVES IN NORTHERN ENGLAND

This document has been written for managers of the 16 forests in northern England that have been identified as red squirrel reserves. By adopting these management guidelines these managers will be playing a crucial part in the strategy to prevent the extinction of red squirrels in mainland England. In places the following advice is rather generic and broad brush to cater for a range of different circumstances. Managers are encouraged to obtain further site specific advice and information on current best practice from their Red Alert Officer. These guidelines have been designed to be supported by a memorandum of understanding and will be reviewed after five years, or, if appropriate, earlier.

Woodland Management

In the absence of grey squirrels and associated squirrelpox virus, food supply is the most important factor influencing red squirrel population density. Reserves should therefore be managed to sustain a continuous red squirrel food supply. Conifer seed is the most important food source for reds in the reserves. Conifer species are of variable quality as a food source and the amount of seed produced depends on the age of the trees and a number of other factors. So forests should be managed to:

- maintain a continuous proportion of the forest composed of stands of seed bearing age;
- ensure that a proportion of species other than Sitka spruce are present in the forest. But note that elevating the proportion of non-Sitka to a high level can make the forest a more suitable habitat for greys, so seek advice if such a change in species composition is being considered;
- ensure that no large seeded broadleaved trees are planted in forests where there are very few already – particularly in those reserves where red squirrel persistence is largely dependent upon habitat management rather than grey control. Small seeded native broadleaves are a welcome addition to forest diversity;
- ensure spatial continuity of forest habitat in designing the shape and location of any large felling coupes;
- seek to avoid felling trees where reds are present and whilst dreys are occupied by young (potentially March – October) where this is likely to significantly impact on the local red squirrel population. (It is recognised that felling an area of a forest or woodland in the summer months may be necessary in some circumstances in order to protect other environmental and/or public interests.)

The above means that forest managers should endeavour to plan felling and restocking over future decades. A long-term forest plan is the suggested approach – advice on this, and possibly funding, is available from the Forestry Commission.

Grey Squirrel Control

The relative importance of habitat management and grey squirrel control varies between the reserves and is likely to change over time. Research is underway on other mammals to investigate alternative methods of population control, such as contraception. This work is in its early stages and such methods of controlling grey squirrel populations will not be available for many years. Culling grey squirrels remains an essential aspect of red squirrel conservation.

Grey squirrels are already present in some of the reserves and colonisation by grey squirrels is likely to be a problem in all of them. An on-going programme of grey squirrel control may be necessary if red squirrels are to survive. It is important for reserve managers to work with their neighbouring land managers in the buffer zones to co-ordinate grey squirrel control work. Help with this and advice on grey squirrel control best practice and information on

training, if this is required, is available from your Red Alert Officer. There is a trap loan scheme that you may like to take advantage of.

- Undertake an appropriate level of well-targeted grey control (using best practice methods) focussing on the dispersal corridors such as river valleys where grey squirrel incursion is likely to start and where trapping is likely to be most productive.

Sightings and Monitoring

Monitoring of red and grey squirrel populations is essential if the effectiveness of conservation work is to be understood.

- Allow and where possible and appropriate, assist in red and grey squirrel monitoring work.
- Report all new sightings of red and grey squirrels to Red Alert.
- It is particularly important that you report sightings of dead red squirrels or those with disease symptoms resembling myxomatosis as this could be squirrelpox virus disease. If you come across a red squirrel carcass, please contact your Red Alert officer as they may wish for it to be sent away for blood tests and post mortem.

Supplementary Feeding

Supplementary feeding is a useful means of drawing squirrels to a known location to increase the likelihood of sightings. Generally, it is not thought to be a necessary or useful means of sustaining red squirrel populations. If considering supplementary feeding please follow these rules and obtain advice from your Red Alert Officer.

- Stop feeding immediately if grey squirrels appear locally.
- Stop feeding immediately if squirrelpox virus is identified in the local squirrel population.
- Ensure proper, regular cleaning of feeders using disinfectant to reduce risk of disease transmission.
- Only use a recommended seed mix and locate feeders appropriately.

Public Access, Enjoyment and Involvement

There is considerable public interest in red squirrels and their conservation.

- Where public access has been agreed, encourage an appropriate level of access for squirrel viewing and provide the agreed facilities and interpretative materials. Your Red Alert Officer can provide information on grants available to support this work and provide information on volunteer red squirrel conservation groups in your area.

Useful contacts for information on grants and further advice

In Cumbria and Yorkshire contact the Red Alert Officer at Cumbria Wildlife Trust on 01539 816311. In Merseyside and Lancashire contact the Red Alert Officer at Lancashire Wildlife Trust on 0151 920 3769.

In Northumberland contact the Red Alert Officer at Northumberland Wildlife Trust on 0191 284 6884.

For information about the England Woodland Grant Scheme contact the Forestry Commission in North East England on 01669 621591, in North West England on 017687 76616 or Yorkshire on 01904 448778.

APPENDIX 6: MANAGEMENT GUIDELINES - RED SQUIRREL RESERVE BUFFER ZONES IN NORTHERN ENGLAND

These guidelines have been written for landowners and managers with land in the buffer zone of a red squirrel reserve. They should help you to understand the actions that need to be taken to help conserve the red squirrel. In places they are rather generic or broad brush so you are encouraged to seek advice specific to your individual circumstances from your Red Alert Officer in order to maximise the effectiveness of your actions whilst respecting other landscape and conservation interests. Grant aid is likely to be available to help you with the costs of this work. Please contact your red Alert Officer for details.

The red squirrel is declining in England and is a priority species for conservation identified in the UK Biodiversity Action Plan. In an attempt to prevent the extinction of the species in England, 16 forests in Northern England will be managed as red squirrel reserves. Each of these reserves is ringed by a buffer zone that is approximately 5km wide. The buffer zone is an area where we will seek to maintain red squirrels in the wider landscape and also deter grey squirrels from establishing and threatening the red squirrel reserves. A buffer zone map has been produced for each reserve. If you manage land in a buffer zone you have an important part to play in the conservation of red squirrels as the persistence of red squirrel populations in the reserves depends, in part, on land management practices and other activities in the buffer zones. All land managers in the buffer zones are encouraged to support red squirrel conservation by following these guidelines.

Land Management

Land in the buffer zones, whether it be farm land or woodland, should be managed to maintain or improve habitat quality for red squirrels without improving habitat quality for grey squirrels. This means that:

- The planting of new large seeded broadleaved woodland such as that composed of oak and beech, is strongly discouraged as this will encourage grey squirrels. In particular, avoid creating such woodland where it is likely to provide an incursion corridor for greys from a buffer zone, or land outwith it, to a reserve.
- An exception to the above is enlargement of ancient and semi-natural oak woodland as this is often desirable for a range of landscape and conservation reasons. However, any such extensions should be limited so as to achieve not more than a 10% increase in large seeded broadleaved woodland in the buffer zone over any 10-year period and enhancement of potential grey squirrel incursion corridors should be avoided.
- In restoring plantations on ancient woodland sites to a native woodland type, do not plant more than 5% large seeded broadleaves, as these will encourage grey squirrels.
- Manage woodland/forests in ways that sustain a continuous red squirrel food supply, e.g. ensure that there is a mix of conifer species and that there are always trees of seed bearing age present.
- Seek to avoid felling trees where reds are present and whilst dreys are occupied by young (March – October) where this is likely to significantly impact on the local red squirrel population. (It is recognised that felling an area of a forest or woodland in the summer months may be necessary in some circumstances in order to protect other environmental and/or public interests.)

Grey Squirrel Control

For the red squirrel to survive in northern England it is essential that land managers in the buffer zones undertake, or allow, an appropriate level of well-targeted grey squirrel control. This should be focussed on wooded corridors where grey control is most needed to prevent or reduce the incursion of grey squirrels to the reserves. Advice on grey squirrel control best

practice and information on training, if this is required, is available from your Red Alert Officer. There is a trap loan scheme that you may like to take advantage of.

- Undertake an appropriate level of well-targeted grey control (using best practice methods) focussing on the dispersal corridors such as wooded river valleys where grey squirrel incursion is likely to start and where trapping is likely to be most productive.

Sightings and Monitoring

Monitoring of red and grey squirrel populations is essential if the effectiveness of conservation work is to be understood.

- Allow, and where possible and appropriate, assist in red and grey squirrel monitoring work.
- Report all new sightings of red and grey squirrels to Red Alert.
- It is particularly important that you report sightings of dead red squirrels or those with disease symptoms resembling myxomatosis as this could be squirrelpox virus disease. If you come across a red squirrel carcass, please contact your Red Alert officer as they may wish for it to be sent away for blood tests and post mortem.

Supplementary Feeding

Supplementary feeding is a useful means of drawing squirrels to a known location to increase the likelihood of sightings. Generally, it is not thought to be a necessary or useful means of sustaining red squirrel populations. If considering supplementary feeding please follow these rules and obtain advice from your Red Alert officer.

- Stop feeding immediately if grey squirrels appear locally.
- Stop feeding immediately if squirrelpox virus is identified in the local squirrel population.
- Ensure proper, regular cleaning of feeders using disinfectant to reduce risk of disease transmission.
- Only use a recommended seed mix and locate feeders appropriately

Public Enjoyment and Involvement

There is considerable public interest in red squirrels. We encourage you to play an active part in the conservation of this cherished species and where possible involve the public in this to increase their understanding, awareness and enjoyment of this beloved character of British wildlife. There may be a local group of volunteers that you can join or work with on your land. Please contact your Red Alert Officer for further information and advice.

Useful contacts for information on grants and further advice

In Cumbria and Yorkshire contact the Red Alert Officer at Cumbria Wildlife Trust on 01539 816311. In Merseyside and Lancashire contact the Red Alert Officer at Lancashire Wildlife Trust on 0151 920 3769.

In Northumberland contact the Red Alert Officer at Northumberland Wildlife Trust on 0191 284 6884.

For information about the England Woodland Grant Scheme contact the Forestry Commission in North East England on 01669 621591, in North West England on 017687 76616 or Yorkshire on 01904 448778.

APPENDIX 7: ANALYSIS OF GREY SQUIRREL TRENDS FROM THE GWCT'S NATIONAL GAMEBAG CENSUS

Statistical Procedure

Analysis was based on all annual shoot returns greater than zero. Shoots contributing only one year's data were omitted. Statistical analysis followed the approach adopted by Whitlock *et al.* (2003) and was carried out using GenStat (Lawes Agricultural Trust, Rothamsted). Grey squirrel cull data were analysed using a generalised linear model (McCulloch & Nelder 1996) with a Poisson error distribution and logarithmic link function, with shoot and year as factors and the logarithm of shoot area as an offset variable. Data were analysed at the UK, country and government office region levels and spanned the period from 1961 to 2006. The year coefficients were exponentiated to give an index of bag size on the arithmetic scale. All index values were relative to the start year, which had a value of 1. To obtain index values for the 1995-2006 period, the index values from the full analysis were recalibrated by dividing by the 1995 value. The 95% confidence intervals around the index values were obtained by bootstrapping at the shoot level: for each of 199 bootstrap runs, shoots equal in number to the original sample were selected at random with replacement and a new set of indices obtained as described above. For each year, the 95% confidence limits were taken as the lower and upper 95th percentiles of the distribution of all 200 index values.

To measure the percentage change between the first and last years of each period, a generalized additive model (GAM, Hastie & Tibshirani 1990) was fitted to the bag indices with one degree of freedom per decade or part-decade then the percentage change calculated from the GAM fitted values for the first and last years. The 95% confidence limits were obtained by fitting GAMs to each bootstrap sample, calculating the percentage change, and selecting the lower and upper 95th percentiles of the 200 values that resulted. If the 95% confidence interval did not include zero, then the percentage change was declared significant at $P < 0.05$ (indicated by * to the right of the percentage change value in the tables in Section 6 of the main report).

This procedure resulted in bag indices and confidence limits from the National Gamebag Census data for the period 1961-2006. Bag indices were expressed relative to the first year of each period, so the index value for the first year of each series is always one. Analyses were carried out for the UK as a whole, at country level (England, Scotland, Wales), and by government office region.

APPENDIX 8: REVIEW OF HUMANENESS OF METHODS TO DESPATCH GREY SQUIRRELS³

A8.1 Introduction

The ideal killing method should be painless, achieve rapid unconsciousness and death, require minimum restraint, avoid excitement, minimise fear and psychological stress in the animal, be reliable, reproducible, irreversible, simple to administer (in small doses if possible), be safe for the operator, and, so far as possible, be aesthetically acceptable to the operator (Close *et al.* 1996). In addition, it should be appropriate for the age, species, and health of the animal. Humaneness can then be surmised from the intensity and duration of pain and distress an animal is subjected to before death or unconsciousness. As these ideal requirements were developed for laboratory animal euthanasia, it is argued that they may not be realistically achievable under field conditions, particularly not when dealing with free-ranging animals. The term killing tends to be used here, rather than euthanasia. Conditions found in the field, however, should not in any way reduce or minimize the ethical obligation of the individual responsible to reduce pain and distress to the greatest extent possible (a view put forward by the American Veterinary Medical Association [AVMA], 2007). The criteria provide a framework on which to base comparisons between methods. Issues concerning the likelihood of failure and associated risk to welfare will also be discussed at the end of this review.

There is little information on the effect of control methods directly on grey squirrels, and the review therefore includes information obtained on other mammal species, or when this is not available, from data on humans. The Littlewood Report (Littlewood, 1965) recommended that procedures (or conditions) which cause pain or distress in humans should also be assumed to do so in animals until convincing evidence is available to the contrary; an approach which has received support from a number of sources (e.g. Bateson 1991, 1992; Spinelli 1991; Zimmerman 1983).

Whilst some argue that in pest control the premise is to kill the most animals for the least effort and that therefore efficiency considerations may override welfare considerations (e.g. Fox *et al.* 2005), there is both a moral and legal responsibility to take animal welfare into account. Under the Treaty of Amsterdam, signed in 1997, animals are formally recognized as sentient beings, leading to a formal responsibility to all member states to take full account of the animals' welfare. A number of Acts, notably the Wildlife and Countryside Act (1981), the Wild Mammals (Protection) Act 1996, and the recently enacted Animal Welfare Act 2006, lay down requirements that have a bearing on which control and despatch methods are permissible and/or the way they can be carried out. These will be quoted where relevant. The Animal Welfare Act 2006 repealed the Protection of Animals Act 1911 (except for certain definitions and the duty to regularly check traps set for hares and rabbits). In addition, the public consensus is that, for the majority of species, lethal animal management practices are acceptable *provided* they are humane.

The killing of female grey squirrels with dependent offspring is an important issue in wildlife management and closed seasons for hunting some species, such as deer, are enforced to minimise welfare concerns. In a 'pest control' context, the imposition of a closed season would probably be unworkable, but the fate of pre-weaned young is an additional welfare cost and raises ethical concerns.

A8.2 Confirmation of (irreversible) unconsciousness and death

An essential factor in lethal control, and common to all methods, is being able to recognize and confirm that an animal is in fact dead. An animal that is merely stunned may appear dead,

³ Adapted and updated from a review in 2008 by CSL for Scottish Natural Heritage (SNH)

but may regain consciousness. All squirrel control operators should be confident in recognizing symptoms of unconsciousness, irreversible unconsciousness and death.

Cranial-nerve reflexes are the most useful in assessing (brainstem) death (Pallis, 1982), as spinal reflexes can occur independently of brain function, for example in animals with a damaged spinal cord.

Unconsciousness and insensibility can be assessed through:

- Loss of posture
- Fixed, dilated pupils
- Lack of pupillary response to a light shone in the eye
- Absence of blinking reflex in response to light touching of the cornea (eyeball)
- Loss of coordinated movements.

Death is indicated by:

- Loss of rhythmic breathing
- Loss of heart rate
- Confirming the onset of rigor mortis.

Except for rigor mortis, no measure on its own should be considered reliable; death must be ensured by a combination of methods. Heart rate tends to persist longer than breathing (even after brain death), but both heart rate and breathing can be difficult to assess if weak and shallow respectively. Similarly, when striking the head to induce cranial concussion (the Sack method), the eyes may be damaged making it impossible to use them as an indicator. If there is any doubt about the confirmation of death, a second method must be used to kill an animal. This is considered good practice (e.g. Close *et al.* 1996).

Indications that an animal is not irreversibly unconscious include rhythmic breathing (which occurs in animals simply stunned and not killed). Vocalisations, a twitching nose, responsiveness to (painful) stimuli and performance of overt behaviours are also indicators that the killing method has failed and the animal may be suffering. The order of events that indicates a return to sensibility is (Grandin 2007):

- Single feeble eye reflex in response to touch (probably still insensible and not conscious).
- Return of rhythmic breathing. This may occur before the corneal reflexes.
- Spontaneous natural blinking without touching (recommended sign for determining return to sensibility).
- Response to a painful stimulus such as pricking the nose with a pin. The stimulus must be applied to the head to avoid confusion with spinal reflexes.
- Righting reflex.
- Fully conscious and sensible. Complete return to sensibility can occur within 15 to 20 seconds after eye reflexes appear.

Twitching and convulsion-like signs may start shortly after killing, particularly if an animal is killed by cranial concussion or shooting. This is a sign that the animal is effectively stunned, although lay onlookers can interpret it as severe distress. An effective stun can be characterised in two phases: the tonic and the clonic phase. In the tonic phase the animal collapses and becomes rigid, there is no rhythmic breathing, and the neck and hind legs may be flexed. The clonic phase, shortly after, is characterised by gradual relaxation of muscles (the animal becomes 'floppy'), paddling or involuntary kicking particularly of the back legs, downward movement of eyeballs and urination and/or defaecation. Death should not be assumed until all signs of reflex activity have ceased, and a second application of the method may be necessary.

Animals sometimes perform a number of protracted gasps before death, particularly if the Sack method is used. The neck normally flexes and the gasps have a guttural sound. These are low-frequency inhalations, called agonal gasps, are very different from normal rhythmic breathing and easy to recognise. But they can be disturbing for lay onlookers. Gasping is a brainstem reflex; it is the last respiratory action before breathing stops altogether (Perkin & Resnik 2002). The gasp causes a pulsed increase in oxygen in the blood (and hence to the brain), which in turn increases strength of the pulse (Gregory 2004). As the pulse gradually loses strength during the interval between gasps, the level of CO₂ in the brain builds up and brings about another gasp, which in turn increases the pulse. Although gasping will not lead to long-term survival, it can delay death, and although the animals are almost certainly unconscious and not suffering, it may be stopped by either concussing the animal again, or by compressing the chest to stop the heart (note that this must be sustained pressure, as mild or repeated compression may have the opposite effect). Death should not be assumed until all signs of reflex activity have ceased.

A8.3 Method review

A8.3.1 Cage (live-capture) trapping

Cage traps are readily available, easy to use and perceived to be inexpensive. Some interviewees expressed concern that 'poorly-made' traps imported from abroad were available and that these were less effective than traps made in the UK (see Minutes of the North Of England Red Squirrel Conservation Steering Group, 19 July 2007). An advantage of cage trapping is that non-target species, including red squirrels, can be released unharmed, although interviewees gave very little information on the number of non-target species caught.

Live-capture traps generally consist of a wire mesh cage with sprung, drop or lift doors (Mayle *et al.* 2007). The mesh size must not be greater than 25mm x 25mm and the wire diameter not less than 1.6mm. Cage traps are available as a single- or multi-capture trap, though single-capture traps are recommended in areas where red squirrels are also present. Respondents claimed they used single-capture traps only. Red squirrels are not deterred from entering traps previously used by grey squirrels, although they may avoid locations visited by dominant individual grey squirrels (Kenward & Hodder 1998, see also section A7.3.3.3); use of single-capture traps will also reduce the likelihood of two or more squirrels being caught at the same time and of then being injured if they fight in the trap.

Traps are usually set on the ground and can be baited with maize or hazelnuts; traps may be set off the ground along tree branches to reduce interference from other animals, but trappers should be aware of health and safety issues if they do so. Trapping sessions usually include a period of pre-baiting prior to setting. Live-trapping can remove at least 90% of resident grey squirrels (Mayle *et al.* 2007). Efficiency was reported in one study to be 28.9 captures/100 trap days (though this is a density dependent measure) (McComb 1984 in Huggins & Gee 1995). Factors that affect trapping success include trap type, position, bait, pre-baiting period, season, weather, trap visit timing and trapper experience (Perry *et al.* 1977, Novak, 1987). A covered cage tends to be more successful in capturing grey squirrels (CSL, unpublished), but at least one operator preferred to leave his traps uncovered.

Best practice in using live-capture traps is set out in Forestry Commission Practice Notes (e.g. Mayle *et al.* 2007). Traps should be checked regularly, at least once, preferably twice, daily, though there are no statutory requirements specifying inspection interval. Wild animals are not protected under Section 2 of the Animal Welfare Act 2006, except when they are 'under the control of man on a permanent or temporary basis'. It is generally accepted that this applies to animals in cage traps, which means that the prevention of harm principle (also referred to as the 'duty of care') becomes applicable. An offence is committed if a person causes unnecessary suffering, the criteria for which are laid down in Section 4 of the Act. The

conduct of pest control ('protecting a person, property or other animal') is considered a legitimate purpose, but any suffering is deemed unnecessary if it could be reasonably avoided or reduced, or is disproportionate to the purpose of the conduct concerned. The section does not apply to the 'destruction of an animal in an appropriate and humane manner' (Section 4(4)), but does suggest that the most humane method should be used at all times, unless there is good reason not to. In all instances it is not necessary to show that the person actually knew that their act or omission would cause suffering, but only that they ought reasonably to have known. This applies to both not checking set traps regularly and choice and performance of the despatch method.

A8.3.1.1 Humaneness of cage trapping

Cage traps in general seem to cause few injuries (Iossa *et al.* 2007) other than abrasions and hair loss on the limbs and snout. This observation is supported by anecdotal evidence from squirrel control operators who estimate injury rate at <1%. Tooth and jaw damage, as well as claw and pad injuries are classed as more severe injuries, and are occasionally encountered in some species (Powell & Proulx 2003). These may cause pain and therefore be a welfare problem, but following best practice guidelines is likely to reduce the chances of them occurring. Covering the cage reduces occurrence of minor injuries (CSL, unpublished). Injury may be more likely when there are two or more squirrels in a trap. Data from badgers suggest that if trap injury occurs it is most likely to occur in the early stages of capture (Woodroffe *et al.* 2005).

Unpublished data (CSL, unpublished) suggest that escape behaviours in an (uncovered) trap were most prevalent in the first hour of capture, with up to 85% of time spent performing behaviours directed towards the cage or cage door. Behavioural analysis of the 5th, 9th and 13th hour of capture showed that this reduced significantly in the 5th and 9th hour, with a trend to increased escape behaviour in the 13th hour (to 17%).

Data on other species (e.g. foxes: White *et al.* 1991; rats: Talling *et al.* 2007) show an increase in glucocorticoid hormones, suggesting that animals experience some degree of stress (which is supported by the performance of escape behaviours by grey squirrels, which is particularly apparent in the 1st hour). It is important to point out that the decrease in escape-related behaviours over time may be due to learned helplessness or fatigue, and does not necessarily mean that stress levels reduce according to the length of time the animal is caught.

Experienced operators claim that once greys have entered a trap that is covered, as per best practice, they tend to remain quiet. They become agitated when the cover from the trap is lifted, so it is recommended that this is done carefully and part of the trap is left covered for the animal to shelter in.

Traps must be set to protect captured animals from flooding, hyper- or hypothermia, adverse weather conditions and harassment by predators (Powell & Proulx 2003). Provided traps are checked at least daily, and they are baited, starvation and dehydration are unlikely to be a problem. However it would be advisable to ensure a greater frequency of checks during very hot weather. Remote devices that signal when a trap is sprung are available to professional pest controllers and may be useful, both in terms of animal welfare and management of labour. However, provisions must be made to ensure that if a device fails, a trap will still be checked (Mason & Littin 2003).

In summary, cage trapping causes few injuries and can be considered humane as long as they are managed appropriately, although it does cause a degree of stress and fear.

A8.3.2 Despatching cage-trapped squirrels

A8.3.2.1 Cranial concussion ('Sack method')

The Sack method is a common way of despatching captive grey squirrels. Each animal is transferred from a cage trap to a medium weight Hessian sack (one at a time). By rolling up the sack, the squirrel can be manoeuvred so that its head lies in one corner and then it can be killed by a blow to the back of the head with a blunt instrument. For a humane kill, it is crucial that the location of the head is assured; the use of thick gloves (to avoid being bitten) may not help to verify this: one suggestion is to cut a small hole in one corner of the sack for the animal to poke its nose through but if it is too large the animal might escape. Operators need appropriate training to perform this method efficiently and to recognise the signs of unconsciousness and death. Some operators may find the method aesthetically unpleasant.

Killing squirrels by concussive blows invariably leaks body fluids into the sack, which may become too bloody after a number of animals have been despatched. There is a potential risk of poxvirus contamination of the ground if blood leaks through the sack – this may be important in red squirrel areas, although the method of virus transmission is unknown (Sainsbury *et al.* 2008). In such cases, clean sacks may need to be carried. Some interviewees stated that they cleaned the trap after a squirrel had been caught.

A8.3.2.1.1 Humaneness of cranial concussion

A single, sharp blow with a hard and heavy, blunted object should be delivered to the cranium. The blow must be of sufficient force to cause a depressed fracture of the skull. A well-positioned blow with enough force destroys the brain, causing instantaneous and irreversible unconsciousness (AVMA 2007). If hard enough death will follow quickly. Unconsciousness should occur as a direct effect of the impact, though secondary effects such as intracranial bleeding or brain swelling tend to also cause death if it is not instantaneous (Gregory 2004). In laboratory animal science, cranial concussion is considered a quick and humane method of stunning rodents, provided it is carried out by experienced and confident operators (Close *et al.* 1997). It is recommended for animals <1kg. The European Scientific Panel on Animal Health and Welfare (2005) supports its use, although on practical and aesthetic grounds it is rated lower than some other methods.

If the first blow does not render the animal insensitive, various degrees of consciousness and ensuing pain can occur (Close *et al.* 1997). A relaxed physical state as soon as the animal collapses and rhythmic breathing may indicate that concussion was shallow and consciousness may resume. One of the main criticisms of this method is that to ensure the animal is in fact dead or rendered irreversibly insensible to pain, the operator must open the Hessian bag and examine the animal. This carries a risk of a) escape if the blow did not incapacitate the animal, b) prolonging any potential suffering if the animal is still conscious, because of the inevitable delay in delivering a second blow. Some practitioners therefore reported delivering a second blow immediately after the first to ensure the animal was dead or rendered insensible (though note that the legality of delivering a second blow appears to be unclear).

In all circumstances, if on inspection an animal is found to be still conscious, a second blow must be delivered without delay or a different method must be applied. The ability to intervene immediately is an advantage over other methods, such as poisoning and tunnel trapping, where such intervention is impractical.

In all cases death must be ensured. Severing of carotid and jugular arteries or cervical dislocation will ensure that the animal dies, though this is purely a secondary method and must never be performed on conscious animals. Cervical dislocation is a humane secondary killing method, but generally recommended only for use on unconscious animals, as animals

are unlikely to be instantaneously unconscious unless associated with cranial concussion (Gregory, 2004). Cervical dislocation is not recommended for use on conscious wild animals.

From the above it can be surmised that two factors are crucial in humane application of the 'Sack' method: 1) operator confidence in being able to deliver a sufficiently strong blow in the right place, and 2) correct presentation of the animal's head to ensure a blow in the right place. The former can be overcome through training on dead animals, but locating the head of a live squirrel inside a Hessian sack may be less easy to simulate. Proponents of the 'Sack' method claim to be confident in locating the head and delivering a sufficiently strong blow to render the animals insensible.

A very limited audit of the 'Sack' method was conducted by independent animal welfare expert James Kirkwood, from the Universities Federation of Animal Welfare. Although his observations involved the despatch of just one animal, he noted that the operator '...gave a firm blow to the animal's head with a heavy metal mallet. In my opinion the accuracy and force of this blow rendered the animal immediately and permanently unconscious. (...) I have no doubt the animal was functionally brain dead from the moment of the blow.' He commented that it was likely to be a reliable system, and that there was no difficulty ascertaining the location of the squirrel's head.

In contrast, opponents of the Sack method felt that they were not confident of locating the head. One concern was that the head might be difficult to find if the squirrel's tail was laid over its head whilst in the sack; in such an event, the tail might also cushion the blow. Clearly, if the squirrel cannot be seen there is an increased risk that the animal might be injured, yet remain conscious. To our knowledge, there is no information on the likelihood of this occurring, and thus about the scale of any potential suffering.

A killing trap, such as the Kania 2000 or DOC250, can be placed at the entrance of the cage trap and the squirrel encouraged to exit the cage trap. Passing through the trap the squirrel is struck by the trap. The benefit of this method that has also been used for despatch of cage trapped mink, is that there is very little training required by the operator. Providing that killing traps that are known to give a good hit almost every time, squirrels will be rapidly insensible. The ease of use of this method and general suitability to field conditions has yet to be assessed, however it has the potential to be the most humane technique for despatch of cage-trapped squirrels.

A8.3.2.2 Shooting at close range

Shooting an animal in the head at close range can be one of the most humane killing methods (Gregory 2004). To kill a caged-trapped squirrel, an air rifle or pistol powered by CO₂ or compressed air appeared to be the weapon of choice of practitioners. The most common calibre was .22in, although some respondents used .177in. Other firearms that were used to despatch squirrels included a .22in LR (cartridge) rifle, .410 shotgun and a 12-bore shotgun, the latter presumably damaging the trap as well! To assist with accurate placing of the shot, a wicket/wooden comb (crush) can be inserted through the mesh of the trap to restrict the movement of the squirrel. Few respondents did this, preferring instead to push the muzzle of the gun through the mesh and then wait for the animal to move into the 'right' position before firing the shot.

The choice of weapon and ammunition is likely to be dictated by company or personal preference. The efficiency of the kill ultimately depends on the competence and experience of the operator. For despatching cage-trapped squirrels, an air weapon combined efficient despatch with operator safety (i.e. minimal risk of ricochet), especially if an air pistol (being less powerful than an air rifle) was used. Under current legislation, air weapons, except those classified as especially dangerous, are not subject to certificate control under the Firearms Act 1968. If more legal controls were to be placed on the possession of air weapons, such as the

introduction of a licensing system similar to that for Section 1 firearms, this might reduce practicality and increase costs.

While air pistols are more convenient to carry around than air rifles, some operators also shoot free-ranging squirrels. This necessitates the use of a rifle, and hence they may not wish or be able to purchase two firearms. A short-barrelled weapon is likely to be more manoeuvrable and easier to bring on aim when shooting through the cage mesh and, in combination with a 'crush' to confine the squirrel in the trap, the risk of a misplaced shot should be minimised.

Shooting organisations, such as The British Association for Shooting and Conservation (BASC) publish codes of practice for use of air rifles and shotguns and provide training courses on the safe handling of firearms.

To be exempt from certificate control, the power (muzzle energy) must be limited to a maximum of 6 ft lbs (8.134 joules) for pistols and 12 ft lbs (16.269 joules) for rifles. Higher-powered rifles can be obtained, but require a Firearm Certificate. Higher-powered pistols are prohibited weapons. However, operators claimed that 'low-powered' air weapons had sufficient power to despatch squirrels efficiently, although it was reported that some types of pellet fired from a .22in air rifle tended to exit, while those from a pistol were usually retained within the body. Clearly, pellets that exit might ricochet off the cage mesh or off a hard surface under the trap endangering the operator or bystanders. In the absence of tests to determine the most appropriate gun/ammunition combination, it is left to the experience of individual operators to balance humane despatch with operator safety.

There is likely to be some leakage of body fluids from shot squirrels even if the pellet does not exit. Thus, there is the potential for the ground below and around the trap to be contaminated with poxvirus, although the mode of transmission between grey and red squirrels is unknown (Sainsbury *et al.* 2008). Informants generally did not consider the risk to be significant and did not take special precautions, although some operators used boiling water to clean traps rather than a disinfectant to avoid leaving an odour that might discourage other squirrels from entering the same traps. An alternative procedure was to transfer a trapped squirrel to another trap before despatching it at a distance away from the original trap site. This avoided leaving blood or other tissue at a location that might be visited subsequently by red squirrels, but to minimise stress, the trapped animal should not be moved far.

Operators that prefer to shoot cage-trapped squirrels should also carry a sack. Squirrels should be placed directly from the cage trap into the sack to confirm death. Squirrels may just have been stunned by the shot, and could easily escape injured unless restrained securely.

A8.3.2.2.1 Humaneness of close-range shooting

Shots must be aimed so that the projectile enters the brain, causing instant loss of consciousness. Immediate irreversible disruption of the respiratory centre is essential so that any possibility of the recurrence of breathing is precluded (Kirkwood 2000). Most airgun pellets are low velocity (i.e. subsonic) projectiles that tend to tear and crush tissues (Gregory 2004). Some are designed to expand inside the target resulting in more widespread damage than from pellets that do not deform. Typically, flat-headed projectiles may not penetrate as deeply as pointed pellets. However, if shot penetration is too shallow, the animal may be concussed rather than killed and over-penetration (exiting) of projectiles reduces the amount of energy transferred to the tissues. Correct placement of the shot is essential and operators who volunteered information on shot placement aimed to strike the top or back of the cranium: by firing vertically downwards onto the top of the head from very close range, a pellet fired from an air rifle or pistol should achieve good penetration through the parietal bones, which are relatively thin and, in rodents, are not covered by a thick temporalis muscle.

There is a risk that, because of the difficulties imposed by shooting through the mesh of the trap, a pellet might strike too far forward than ideal in a proportion of cases (Kirkwood 2000). An alternative point of aim is the back of the head with the barrel pointing slightly forward so that the shot penetrates the occipital bones and destroys the brain stem. Bones are likely to shatter when struck by a projectile and the resulting bone fragments may act as secondary missiles resulting in more tissue destruction.

There is a risk that at the moment of firing the animal moves and the shot will be misplaced. Consequently, the animal may not be rendered unconscious but is injured, or it may only be stunned. If the spinal cord is struck and there is minimal bleeding, the animal may appear to be dead, but is in fact paralysed, alive and conscious (Gregory 2004). Occasionally, the shot may miss completely, but to our knowledge there is no information about the likelihood of this occurring.

Under any of these circumstances, the need for a second killing action is required. Kirkwood (2000) considered that to minimise suffering, a second shot should be fired without delay, but that is only possible with certain types of firearm such as those with a magazine that holds two or more rounds (e.g. revolvers or semi-automatic weapons). Because of their design, single-shot weapons are likely to take the longest time to reload and thus cause a delay in delivering a second and, if necessary, a third shot. The legality of firing a second or third shot with respect to welfare appears to be unclear. If the animal is still conscious then the most appropriate action would be to deliver a second shot. Removing the animal from the cage trap would be difficult and it may escape.

In all cases, squirrels must be removed from the cage trap and death must be confirmed after shooting. Any unconscious animals should be killed by cranial concussion, and a suitable implement for this should be carried at all times.

A8.3.2.3 Lethal injection

Some respondents took trapped squirrels to a local veterinary practice, where the animals were despatched by lethal injection, but the cost of this service was seen as a disincentive to use it. The most commonly used and accepted drug for this purpose in veterinary practice is sodium pentobarbitone, which is a controlled drug under Schedule 3 of the Misuse of Drugs Regulations 2001 and not available to the general public. Opinions obtained from the Royal Veterinary College and the Veterinary Medicine Directorate are that full-time GSCOs and others engaged in control are unlikely to be allowed to carry sodium pentobarbitone under an exemption (similar to one granted to RSPCA/SSPCA officers). Thus, captured squirrels will have to be taken to a veterinarian, or have a veterinarian present at despatch, but neither is practicable nor economically viable if large numbers of squirrels must be killed. In addition, the extra handling and transport to a veterinary clinic would be particularly stressful for a wild animal.

Animals despatched with this method should be incinerated or rendered, as they can pose a risk to non-target species if left in the woods.

A8.3.2.3.1 Humaneness of lethal injection

Sodium pentobarbitone is a barbiturate and acts by depressing the central nervous system, causing cardiac and respiratory arrest (Close *et al.* 1996). Following intracardiac use, unconsciousness is almost immediate and cardiac arrest follows within 10 seconds. However, intra-cardiac injections are painful, and can be difficult to perform correctly. If the heart is missed there is a risk of injecting the pentobarbitone into the lungs instead (Gregory 2004) and this causes significant welfare issues. For these reasons, injection of pentobarbitone in the heart should only be used on animals that are already unconscious.

For smaller mammals and other vertebrates, intraperitoneal (IP) injection of 200mg/kg at 18% (Close *et al.* 1997) pentobarbitone solution is recommended. Following intravenous injection unconsciousness follows in approximately 15 seconds and death (as assessed from EEG) follows five to 30 seconds later (in dogs: Evans *et al.*, 1993). Intraperitoneally, euthanasia is achieved in three to 10 minutes. If the dose given is too low, deep narcosis rather than death may occur. Careful examination is required; if heartbeat or respiration does not cease, an additional dose of anaesthetic may be given (intraperitoneal or intracardiac) or a physical method may be used to ensure that death has occurred. This method is unlikely to fail as due to its legal status, only trained persons can use sodium pentobarbitone. There are some concerns over pain associated with IP injection, as sodium pentobarbitone may cause irritation of the peritoneum (Close *et al.* 1996; Svendsen *et al.* 2007)

A8.3.2.4 Drowning

There were unconfirmed reports that occasionally trapped squirrels were drowned, hence drowning is reviewed here. Drowning is defined as ‘suffocation by submersion, especially in water’ (Modell 1993). It is considered by many to be illegal in the UK, but if used to kill an animal taken in the course of legal pest control it may be legal if it is ‘reasonably swift and humane’ (Wild Mammals (Protection) Act 1996).

The advantage of drowning is that it needs no additional equipment; the whole trap can be submerged, requiring no handling of the animals, though clearly it is only practical when there is sufficiently deep water in the vicinity. It is a reliable method in that, if submersed for long enough, all animals will die, though death must be confirmed. It is relatively safe for the operator, and as they do not need to watch the animal during the process it may be aesthetically acceptable. Also, there are no adverse effects on either the environment or non-target species.

A8.3.2.4.1 Humaneness of drowning

Generally, submersion in water initially causes breath-holding, accompanied by an increase in heart rate (tachycardia). Within seconds this is followed by profound hyperventilation and hypercapnia (elevated levels of carbon dioxide in the blood) (Datta & Tipton 2006). The hyperventilation response is most pronounced during submersion in cold water (at temperatures realistically encountered in the wild), where the cold-shock response overrides the breath-holding response (Golden *et al.* 1997). Death is caused by anoxia (lack of oxygen in the blood and body) (Modell 1993).

Time to unconsciousness for squirrels submerged in water is unknown, but in line with other terrestrial mammals it can be expected to be a few minutes (Ludders *et al.* 1999). People become unconscious in two to three minutes, followed by death in four to 10 minutes (Stone 1999) – these durations may be shorter for squirrels due to their smaller size. Crucially, the time to unconsciousness and insensibility to pain cannot be conclusively known, although Ludders *et al.* (1999) suggested that narcosis does not occur before the effects of anoxia (absence of (useable) oxygen in the tissues) set in; the effects of anoxia are not aversive in humans (Gregory 2004). Reports from people that have recovered from either accidental drowning or suicidal drowning differ in their description of the feelings experienced. Some people feel terrible pain and burning sensation, whereas others describe no pain before drifting into unconsciousness (Stone 1999), although there is likely to be some retrospective amnesia due to the effects of anoxia (Gregory 2004).

Behaviourally, drowning induces struggling and is almost certainly associated with stress. This is supported by the measurement of increased levels of catecholamines in submerged dogs (Conn *et al.*, 1995).

Death must be confirmed after drowning as recovery can occur, particularly in cold water when oxygen requirement of the brain is thought to be reduced (Modell 1993). However, if left submerged sufficiently long, drowning is a reliable despatch method.

Drowning is a publicly controversial despatch method and generally not recommended. The Forestry Commission guidelines state that it is illegal, though this can be disputed. It is not an approved method of euthanasia for animals in research (Close *et al.* 1996) and in the guidelines of the American Veterinary Medical Association is considered inhumane. Based on human experiences, it cannot be assumed that drowning is painless for squirrels. In addition, there is evidence of a clear stress response in terrestrial mammals subjected to drowning, and this can be expected to be similar in squirrels. Though arguably drowning may be more humane than poisoning with warfarin, based on these findings above and the fact that other killing methods which cause more rapid unconsciousness, are available (and practical) in the field, drowning should only be used in emergency situations when other faster-acting methods are unavailable.

A8.3.3 Other methods of control

A8.3.3.1 Shooting free-ranging squirrels

Control methods other than live-trapping are necessarily limited when there is a risk that red squirrels might be killed instead of grey squirrels. The option most respondents used was 'long-distance' shooting, usually using a rifle to shoot squirrels on the ground or on the lower parts of tree trunks, but a few operators shot squirrels high up in trees as the animals emerged from the dreys (drey poking and shooting). The nests of grey (and red) squirrels (dreys) consist of a hollow ball of twigs lined inside with moss, leaves and dry grass. They are constructed several metres above ground close to the trunk of a tree or in a fork in the branches. Drey poking and shooting is carried out by disrupting the nests with long poles and then shooting any squirrels that run out attempting to escape. Drey poking and shooting should be conducted in late February/early March when there are no leaves on the trees. One or two people may be deployed to poke the dreys, while two to three shooters, armed with 12- or 20-bore shotguns, surround the tree and shoot escaping squirrels. As the presence of steel shot degrades timber, non-steel shot is recommended. Squirrels that are not killed outright must be quickly and humanely despatched. If animals are still mobile, dogs may be helpful in preventing them from running back into the trees. Only dogs that are proficient in catching and quickly killing squirrels should be used.

Drey-poking and shooting alone is considered to be generally ineffective as a measure to prevent tree damage, as it can only be carried out when the canopy cover is low and the animals killed will be replaced before the summer damage period (Mayle *et al.* 2007). It may be more effective if followed up with trapping, but an 8-year campaign of drey poking and shooting combined with cage trapping in the New Forest proved to be ineffective (Gurnell & Pepper 1998). Shooting squirrels seen at food hoppers or cage traps is regarded as counterproductive, as it might deter other squirrels from visiting the traps and hoppers, however there is no objective evidence to support this. Shooting appears to be most effective for removing the occasional 'nuisance' squirrel.

Shooting organisations, such as The British Association for Shooting and Conservation (BASC) publish codes of practice for use of air rifles and shotguns and provide training courses on the safe handling of firearms. Shotguns and rifles, other than low-powered air rifles, are subject to certificate control under the Firearms Act 1968 and rifles and some semi-automatic shotguns are more strictly controlled than double-barrelled shotguns. It was reported that some considered drey-shooting using shotguns was too labour-intensive and suggested that a volley of rifle bullets, such as hollow-point .22inLR, could be fired by one to two shooters into a drey that was known to be used only by grey squirrels. Presumably, the weight and speed of the bullets, with more penetrative power than small shotgun pellets,

would be sufficient to break through the drey structure. However the chances of missing the squirrels completely, or merely wounding them must be very high. Indeed, such practice is highly questionable from an animal welfare perspective as without a clear view of the target, it would be more difficult to place a shot in the head or chest, which would ensure a quick kill. In addition it must carry a serious safety risk, as it would be difficult to know with certainty where bullets that travelled through the canopy would land.

In addition to the serious welfare concerns, another problem is how to establish that grey squirrels occupy the drey and not other species. Most respondents were unable to distinguish with certainty the dreys of red and grey squirrels based on size, location and structure, but a few claimed they could. Drey-shooting also risks disturbing nesting birds and accidental injury to non-target species. Not surprisingly, respondents were reticent about the number of animals shot accidentally. It is perhaps inevitable that non-target animals will be shot by mistake, but there is no agreed baseline on what is considered 'acceptable'. As an example, of 2,658 animals shot during a trial to control the Ruddy Duck, seven were non-target species representing less than 0.3% of the total (CSL 2002).

A8.3.3.2 Humaneness of shooting at a distance

Shooting can be a quick and effective means of killing animals humanely. Headshots are preferable, because, when correctly placed, they cause an instant loss of consciousness (see section A7.3.2.2.1). However, this is only practicable when animals are immobilised by injury or restraint, although some shooters may feel confident about their abilities to aim at the head from afar. In general, if striking the head is too difficult, hunters may then aim for the neck, or the chest as that is the bigger target. To minimise suffering, the animal should be broadside to the shooter so that the bullet passes through the heart and both lungs (Urquhart & McKendrick, 2003). Death from a shot to the chest is due to massive tissue damage and haemorrhage from major blood vessels. Insensibility will occur after an interval ranging from a few seconds to a minute or more (Sharp & Saunders 2004). If a shot stops the heart functioning, the animal will lose consciousness rapidly, but if the spinal cord is damaged above the fifth cervical vertebra and there is minimal bleeding, the animal may die from being unable to breathe (Gregory 2004).

For reasons of safety, a shotgun is probably the most appropriate weapon for shooting upwards at squirrels escaping from dreys, as pellets that miss the target will not travel too far. A shotgun also requires less precise aiming than a rifle. Shotgun ammunition consists of small pellets of lead, steel, bismuth, tungsten composite or other materials. The size of individual pellets varies according to the type of cartridge. One informant suggested that shot size 5 or 6 might be suitable for shooting squirrels; each pellet of size 5 is approximately 3 mm in diameter and each cartridge contains many pellets. On firing, the pellets exit the barrel more or less as a single cluster, but as distance increases the pellets spread out. An animal aligned with the central mass of pellets may be fatally injured, but one on the periphery of the shot pattern may be struck by one or two and survive (Gregory 2004). The terminal energy may not be sufficient for a pellet to penetrate deeply enough to cause a fatal wound. Shooting of game by shotgun has raised some concern following a demonstration that for certain species one animal was wounded for every one killed (Noer *et al.* 2007). In this case, to reduce wounding, a maximum range was recommended. In a study looking at fox shooting, as shooters' skill level increased, the 'kill' rate increased and there were fewer misses, but the wounding rate remained unchanged (Fox *et al.* 2005). Shotguns 'killed' less than rifles, because of poor pellet penetration or poor shot pattern densities. An air rifle or shotgun pellet that does not kill may become surrounded in soft tissue by fibrin, which has no blood supply (Gregory 2004). This minimises the inflammatory response and stops the pellet migrating through the body. However, this does not happen to pellets lodged in joints and may lead to chronic irritation, particularly if the pellet is made of lead or steel. This causes chronic pain thus constitutes a significant welfare concern. A pellet or bullet that passes through the

abdomen may perforate the intestine. This would lead to development of peritonitis over several days and subsequent death from the infection.

There will always be a risk that the first shot will be misplaced and the need for a second or third shot will be required. Double-barrelled or semi-automatic shotguns have the facility to fire a second shot without delay. A repeating air rifle should be preferred to one that takes time to charge, load and fire. Informants used air rifles to shoot free-ranging squirrels that had come down to ground level. There was no information on the number of squirrels that required a second shot or what was considered to be the maximum effective range. In practice, some shooters may be confident of their abilities to shoot squirrels at ranges that others would find challenging. It would be useful to find out the number of animals that were wounded and escaped, as well as examining the wound tracts of shot squirrels in order to determine the extent of tissue damage and the likelihood of animals being rendered insensible quickly.

A8.3.3.3 Kill-traps

Very few respondents used spring traps (kill-traps), but the RSPP has recently started deploying them (Fenn traps in wooden boxes). Spring traps (also called tunnel traps due to the requirement that they need to be protected to prevent, as far as possible, non-targets being caught) are regulated through the Spring Traps Approval Order 1995 and subsequent amendments (The Spring Traps Approval (Variation) Order 1988 and the Spring Traps Approval (Variation) (England) Order 2007). Currently, 20 spring traps are legal to use against squirrels, provided setting instructions are adhered to. Not all approved traps are still available for sale. In October 2007 six new traps were approved for use on squirrels in England only. Most commonly used traps in squirrel control tend to be BMIs, Fenns or Kaniacs. Tunnel trapping is not recommended in areas where red squirrels or other protected species are also present (Mayle *et al.* 1997). It is an offence to set in position any trap calculated to cause bodily injury to any wild animal, including the red squirrel, listed in Schedule 6 (Wildlife & Countryside Act, 1981). Some interviewees were convinced that red squirrels would not enter traps previously used by grey squirrels, although this is partly contradicted by a study carried out by Kenward & Hodder (1998).

Training or experience is required to be able to identify suitable sites to set kill-traps, after which little further training is required. However, operator practices remain an extremely significant factor in trap success (Powell & Proulx 2003). Exchanges of experience between trappers or a training period with an experienced trapper may improve capture rate. It will also maximise humaneness, as a well-placed trap will increase the chance of a good strike. Traps may be set in trees to increase selectivity, but there are clearly H&S issues with placing traps too high. Depending on where and how the jaws of a spring trap strike the body of a squirrel, there is a risk of leakage of bodily fluids and thus the potential to spread the pox virus.

A8.3.3.4 Humaneness of kill-trapping

Ideal killing traps deliver a consistent strike that renders an animal insensible immediately. There are three ways in which spring traps can kill the target animal. The most humane type is one that strikes the animal with sufficient force to cause cranial or upper vertebra destruction; this is dependent on sufficient impact force of the trap being delivered to the correct anatomical location. The other two ways that spring traps can cause death are a result of the clamping force of the trap. If the kill bar is located across the neck of the animal this can shut off the flow of blood to the brain. Alternatively, if the kill bar is located across the body, thoracic compression occurs resulting in death from hypoxia (through lack of respiratory function).

Although international standards exist regarding the humaneness of traps (both killing and restraining traps – Agreement on International Humane Trapping Standards), these are aimed

at furbearers important in international trade. However, they may be used as a template for other species for which traps are used such as squirrels. In these standards a killing trap is deemed acceptable if it causes irreversible unconsciousness within 5 minutes, in at least 80% of tested animals. In relation to welfare, even using these standards, unless the trap causes instant unconsciousness there will be a time of up to 5 minutes where the animal will be in severe pain.

Further welfare issues arise when a trap causes injury rather than death, and if there is a likelihood of escape of an injured animal (Iossa *et al.* 2007). This makes it essential to check traps regularly, at least daily (Mason & Littin 2003). Animals caught by an extremity will experience immediate pain, followed by transient numbness and progressively worsening ache due to the occlusion or injury of major blood vessels and nerve depression (Gregory 2004). Pain can become more intense if venous pressure is raised because of restricted venous return. Haemorrhage and swelling, either at a wound site or associated with a body hit that injured but did not kill, also cause pain through accumulation of pressure or 'restricted venous return', where pain-provoking substances cannot be removed from the injury site. In people, haemorrhages are almost always associated with pain or severe pain. There is no clear relationship between mortality and blood loss through haemorrhage, unless this exceeds 40% (Gregory 2004). If the injury includes deep tissue trauma such as bone fractures, this is likely to be associated with immediate pain or an initial feeling of numbness followed by pain. In addition to pain, animals will suffer significant fear and possible cardiogenic and hemorrhagic shock, which in people causes anxiety and depression (Gregory 2004). In addition to causing pain, being caught without being killed causes severe stress.

Fenn traps have received mixed reviews for use on squirrels and other species, with laboratory testing of this trap consistently failing to render 70 or more percent of animals (not squirrels) irreversibly unconscious in less than three minutes (with 95% confidence) (Powell & Proulx 2003, Iossa *et al.* 2007; Warburton *et al.* 2008). Feedback from one practitioner on performance of Fenn Mk IV trap on 65 squirrels in the field showed that the trap did not consistently hit the animals in the optimum place, with the result that some animals were found alive. This was least when animals were hit at neck level (this can be classed as an optimum hit; one out of 26 was found alive at checking), and most when hit at either shoulder or hind limb (2/2 and 17/17 respectively found alive). When caught at a front limb, only one out of 14 animals had died by the time the trap was checked. Although there is the belief (though no hard evidence) that a Fenn trap may be more effective (i.e. better at catching) than some other traps, the humaneness of this trap is questionable. The BMI was perceived well by practitioners who used it, although Huggins (1999) raised concerns over how quickly fox squirrels were killed in this type of trap.

Practitioners who used the Kania 2000 gave favourable feedback. It is a powerful (baited) trap that seems to show good results in achieving a swift kill. In the only reported laboratory test, it quickly rendered 13/14 marten insensible (within three minutes), though in subsequent field tests it proved more variable (Proulx, 1990 and 1991 respectively).

The DOC traps, approved in England in 2007, cause extensive destruction of the brain. It has been tested and passed (on animals other than grey squirrels) in New Zealand according to their National Animal Welfare Advisory Committee standards (causing consistent irreversible unconsciousness in less than three minutes in all species it was tested on). It has the potential to be one of the most humane traps for squirrels, as trap systems designed to crush the skull are said to be the most efficient and humane (Mason & Littin 2003). For example, when mink were caught, time to irreversible unconsciousness was decreased if the skull rather than the neck was damaged (Proulx & Barrett 1991).

In summary, only traps that have the potential to pass international standards of rendering an animal insensible quickly should be used. These include the Kania 2000, Kania 2500 and the

DOC traps, though currently only the Kania 2000 is approved for use in Scotland. The humaneness of Fenn traps is questionable.

A8.4 General issues related to culling methods

This review has focussed on welfare issues associated with methods currently being used to control grey squirrels. Whilst there is information on the potential suffering that could result if despatch methods are incorrectly applied, there is little or no information on how often suffering (both duration and severity) occurs in practice (e.g. the number of misplaced shots as a proportion of the number of shots on target, the number of foul captures in spring traps compared with the number of animals killed instantly). To be able to make a realistic assessment of the risk to welfare of each method under field conditions, both factors need to be known. For instance, the consequences of a misplaced blow or shot to a cage trapped squirrel are that an animal may suffer severe pain for a varying period of time up to 5 minutes, but if in reality the number of times this happens is low (as indeed those practitioners who use the method claim), then the actual risk to welfare in the field might be deemed to be acceptable. However, if it was found that misplacements are common, then this method of despatching cage trapped animals, may be unacceptable, regardless of practical issues or cost. If the control of grey squirrels is found to remain an integral and essential part of red squirrel conservation, then the public will need reassurance that the most humane methods are being used competently; otherwise their support may not be forthcoming.

Public bodies, including charities, should be promoting a method of squirrel control that they know to be acceptable with regard to the welfare of the target animal. Although the Forestry Commission has provided some guidance, this is not based on objective welfare assessments of the methods. Although not all practitioners would necessarily follow this advice, the majority of the general public tend to follow guidance wherever it is given.

The likelihood of a method failing is influenced by a number of factors, including operator expertise and confidence. To minimise failures and thus maximise humaneness, these factors need to be recognised and, as far as is practicable, controlled through appropriate training and the availability of suitable equipment. This is important even if failures occur infrequently. However, unpredictable events such as sudden loud noises can cause the squirrel to move suddenly at the moment of delivering a shot or a blow, and realistically, it is impossible to guarantee 100% reliability for any method (though clearly, this should always be the aim).

The issue of a failure occurring infrequently has been addressed during development of international standards on humaneness of spring traps, e.g. the Agreement on International Humane Trapping Standards. These standards specify a level at which a trap passes humaneness criteria despite not being 100% effective. For example, a particular trap may pass a test if it kills X% of animals humanely (as specified by a killing time), X% of the time, where both Xs should be as high as possible.

A parallel example is the stunning of animals in slaughterhouses. Despite assurances of correctly maintained stun guns and experienced stun gun operators, it has been recognized that the efficacy of the first shot is not always 100%. In an audit, if the efficacy of the first shot is 99% to 100%, this is rated as 'Excellent', and if 95% to 98% as 'Acceptable' (Grandin 2005). Efficacy below 95% is unacceptable, and the slaughter plant would fail the audit. Currently, such audits are carried out in internationally operating slaughterhouses in the USA and New Zealand. A similar principle could be used in deployment of methods in squirrel control (based for instance on current and potential performance levels of each method), though ultimately what level is (un)acceptable is a policy decision.

There has been some debate as to whether a person is liable to prosecution under the Wild Mammals (Protection) Act 1996 or the Animal Welfare Act 2006 for delivering more than one blow or shot. The concern is that delivering two or more blows might be viewed as

‘beating’ an animal to death or that delivering two or more shots could be seen as prolonging suffering. This concern was often expressed during a recent review of squirrel control methods by CSL for SNH. One pest controller, operating in England, explained that he always fired two shots without delay at each squirrel as insurance, regardless of the effect of the first shot. Similarly, some practitioners using the Sack method may always deliver two quick blows.

The Wild Mammals Protection Act 1996 makes it an offence to beat any wild mammal with intent to inflict unnecessary suffering, though this does not apply if killing was carried out in a ‘swift and humane manner’ in the course of a ‘lawful pest control activity’. The Animal Welfare Act 2006 (Section 4) states that an offence is committed if a person causes a protected animal unnecessary suffering by an act and knew that the act would have caused the suffering or be likely to do so. However, Section 4(4) states that this does not apply to ‘the destruction of an animal in an appropriate and humane manner’.

Conceivably, the key issues in any prosecution case would be the humaneness of the method used, intent and the likelihood and severity of suffering. As the Animal Welfare Act is relatively new there is little case law available on which to base any advice. Although the Wild Mammals Protection Act 1996 is older, it appears to have been rarely used. A search through the Polis database for Parliamentary Questions regarding prosecutions under this Act revealed that between 1998 and 2000 there were 13 prosecutions and 7 in 2006. The apparent vagueness of the wording in the Acts has clearly led to uncertainty for some operators regarding their vulnerability to prosecution if they fire two or more shots or deliver two or more blows. This reinforces the need for an independent audit on the welfare of squirrels despatched by each of the methods in the field. It is considered that any uncertainty related to having to apply multiple applications of a method must be addressed to inform and reassure practitioners.

To maintain a high standard of animal welfare during control operations, all personnel should have access to appropriate training and be competent 1) to use killing techniques, 2) in handling and restraining squirrels, 3) appreciate how applying a method affects the animal, 4) have a clear understanding of the mechanism by which the method kills and 5) recognize signs of an efficient stun and kill (AVMA, 2007). Detailed Standard Operating Procedures (SOPs), similar to those employed in the Defra Randomised Badger Culling Trials (RBCT), may be particularly useful for squirrel control operators. SOPs provide step-by-step advice on how to best carry out a despatch, and serve to reinforce best practice. They may be based on current practice if this is found to be sufficient.

Once SOPs have been designed, tested, where needed adjusted, and distributed amongst staff (including training where necessary), an objective assessment (audit) of despatch methods may be carried out to assess performance in the field and identify areas where improvements should be made (cf. Defra RBCT).